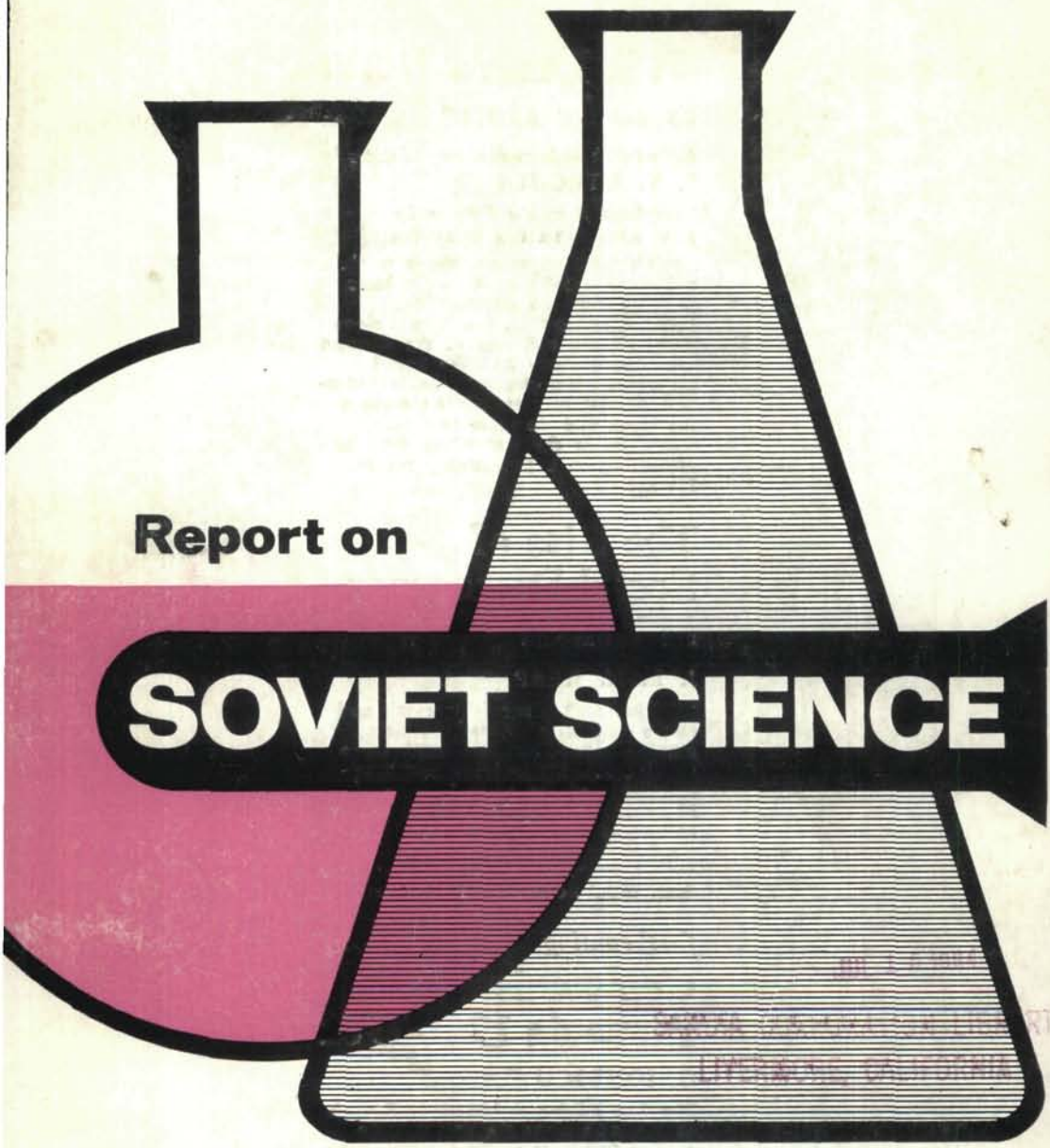

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CYBERNETICS IN THE SOVIET UNION

Loren R. Graham

> *Cybernetics is a new science which is being more and more widely used. It aspires to the study of the processes of control occurring in nature, industry, and human society, that is, to the coverage of practically all human activity; for this reason, we demand that the ideological basis on which this science develops in the Soviet Union be impeccable.*[1]
>
> Academician A. I. Berg, Chairman of the Scientific Council on Cybernetics of the Academy of Sciences of the USSR

THE eighteenth-century French physician and philosopher la Mettrie believed that the operation of the human brain could be completely explained as an organic materialistic process. The human soul, he said, was merely the product of the organs of the body; nothing existed aside from matter, moving in accordance with the laws of mechanics. La Mettrie's views caused such an outcry from the religious and civic authorities that his books were banned and he was forced to flee the country.

Since those days, the scientist's knowledge of the brain, as well as his knowledge of non-human control systems, has so deepened that la Mettrie's writings are of only historical interest to us. Nevertheless, the emotions which his views provoked retain their force. The new science of cybernetics seeks to establish valid generalisations covering the operation of control systems both in living organisms and in machines. The cyberneticists have been more cautious, and certainly more sophisticated, in their generalisations than the eighteenth-century materialists; indeed, many would deny any kinship with them, but they have aroused similar responses. In particular, wherever cybernetics has come in contact with established philosophical systems claiming universality, some conflict has occurred. Such was the case in the Soviet Union, where cybernetics has been the focal point of intense controversy.

Cybernetics found no home in the Soviet Union in the decade after the second world war even though Soviet scientists were pursuing many lines of computer research.[2] The attitude towards cybernetics was defined in 1953, when an anonymous author published a blistering attack on cybernetics in the major Soviet philosophical journal.[3] He maintained that cybernetics was *too* materialistic, that is, vulgarly materialistic in the manner of la Mettrie, when it suggests that there is

[1] A. I. Berg (ed.), *Kibernetika na sluzhbu kommunizma* (Moscow, 1961), p. 11.

[2] This generalisation is valid even though several Russian scientists (I. P. Pavlov, A. N. Kolmogorov, N. M. Krylov, N. N. Bogoliubov) made theoretical contributions to cybernetics.

[3] Materialist [pseud.], 'Komu sluzhit kibernetika', *Voprosy filosofii*, No. 5, 1953.

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no difference of principle between organic and inorganic cybernetic mechanisms; cybernetics was throwing science back two hundred years. The most complex cybernetic 'turtles' or robots of the types constructed by Claude Shannon and Grey Walter were only mechanical gadgets, and could never display the conditioned reflexes of animals or man; the Western cyberneticists had misinterpreted the teachings of the great Russian scientist I. P. Pavlov, who discovered the subtleties of conditioned reflexes in organisms. Finally, cybernetics in the West was said to serve the interests of the capitalists, who desired to increase their profits through automation of industrial processes.

This lengthy criticism of cybernetics appeared shortly after the death of Stalin and before the relaxation of some of the political controls over intellectuals. In the previous years not only cybernetics but certain developments in many other sciences, including physics, chemistry and genetics, had been labelled 'bourgeois perversions'. After 1954, however, scientists were permitted to defend themselves from such attacks. Cybernetics was proving such a fruitful field of endeavour that the Soviet Union could remain aloof only if it were willing to sacrifice national strength to ideology. The application of cybernetics to industry as well as to strategic purposes was proceeding in the West at a rate which fully justified the cyberneticists' claim to a 'second industrial revolution'. The first industrial revolution had grown from improved methods of transforming and transmitting energy; the second revolution grew from superior means of transforming and transmitting information.

A year later, in November 1954, a Soviet philosopher and mathematician, E. Kolman, stoutly defended cybernetics before the Academy of Social Sciences of the Central Committee of the CPSU.[4] He attacked the articles which had appeared earlier in Soviet journals condemning cybernetics as a false science. It is true, Kolman stated, that Norbert Wiener, the father of cybernetics, espoused many incorrect philosophical and political views; in particular, Wiener was a follower of American pragmatism, a false philosophy which asserted that 'what is true is what is useful'; Wiener's followers were completely incorrect when they tried to convert cybernetics into a 'universal science'. Nevertheless, not all of Wiener's work should be condemned because of his personal failings; cybernetics was a scientific development of paramount importance which could be compared in significance with the introduction of the decimal system, or the invention of printing. If the Soviet Union continued to ignore cybernetics, it would be failing to recognise a technological revolution.

FROM 1954 to 1958 Soviet scientists and philosophers debated the legitimacy of cybernetics. Some noted correctly that there was no accepted definition of cybernetics; much of the debate was a fruitless attempt to agree on terms. Increasingly, however, leading Soviet

[4] The lecture was later published as 'Chto takoe kibernetika?', *Voprosy filosofii*, No. 4, 1955.

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scientists shifted from attack to defence. Academician Kolmogorov, a mathematician, at first spoke out sharply against cybernetics, but in April 1957, at a meeting of the Moscow Mathematical Society, he admitted that he had not really understood cybernetics previously and now supported it.[5] In 1958 he wrote a laudatory article on cybernetics for the supplementary volume of the *Large Soviet Encyclopedia* (it had carried no entry on cybernetics previously). Later he became such a convert that he was quoted in the Soviet press as saying, 'I belong to those extremist cyberneticists who see no fundamental limitations to the problem of life in the cybernetic approach and who believe it is possible to analyse life in all its aspects, including human consciousness, by cybernetic methods'.[6]

The movement towards cybernetics became a landslide. In April 1958 the Academy of Sciences created the Scientific Council on Cybernetics, headed by Academician A. I. Berg, which included mathematicians, physicists, chemists, biologists, physiologists, economists, psychologists, linguists and jurists. The Academy's Institute of Automation and Telemechanics began directing most of its research towards cybernetic applications. The Moscow Power Institute, one of the largest and oldest engineering institutions in the country, with an enrolment of 17,000 students, devoted approximately one-third of its instruction and research to cybernetics. Soviet students were urged to major in cybernetics, and Soviet science fiction was filled with descriptions of 'cybernetic brain-modelling' and the 'cybernetic boarding schools' of the future. The Academy of Pedagogical Sciences of the Russian Republic established such an experimental boarding school in Moscow to prepare children from an early age for careers in cybernetic programming. The Communist Party welcomed cybernetics as the rational way to control man's environment and lighten his labours.

In 1961 Academician Berg edited a book entitled *Cybernetics in the Service of Communism* in which Soviet scientists outlined the potential applications of cybernetics in the national economy. In his introduction he argued that no country would be able to utilise cybernetics so effectively as the Soviet Union; since cybernetics consists largely of the selection of optimum methods of performing operations, only a socialist economy could incorporate these methods universally. 'In a socialist planned economy all conditions are present for the best utilisation of the achievements of science and technology on behalf of all members of society rather than for various competing groups and the privileged minority.'[7] He then discussed the most promising uses of cybernetics in the Soviet Union.

[5] E. Kolman, 'O filosofskikh i sotsialnykh problemakh kibernetiki', in V. A. Ilin, V. N. Kolbanovskii, and E. Kolman (eds.), *Filosofskie voprosy kibernetiki* (Moscow, 1961), p. 90.

[6] A. N. Kolmogorov, 'Automatic Machines and the Life Process', *The Soviet Review*, July 1962, p. 41.

[7] Berg, op. cit., p. 8.

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One application of cybernetics envisaged by Academician Berg is medical diagnosis. As early as 1956 Soviet researchers were feeding clinical information to electronic computers which were then asked to provide diagnoses based on various complexes of symptoms noted in the patients. The advantages of computers in medical diagnosis are that they have a much greater memory capacity than an individual doctor, and can approach diagnosis with a statistical exactness which a doctor can only approximate. Thus, on the basis of clinical histories, it may be shown that a certain symptom appears in 98 per cent of the cases of one disease, in 37 per cent of another, and in only 2 per cent of another. If a patient displays a series of symptoms, each with a different disease-probability ratio, a computer can arrive at a probable diagnosis which is a valuable supplement to the diagnostician's own judgment. The machines are capable of producing several possible diagnoses for one patient, and on a few occasions have indicated that one patient was suffering from more than one disease, contrary to earlier opinion.[8]

The theory of information can also be applied in a multitude of ways to industry. For example, the amount of electrical power needed to supply machinery is usually calculated as the sum of the maximum power needed for each establishment. However, as is well known, electrical machinery goes through cycles; only at certain moments is maximum power needed. Providing maximum power constantly throughout the entire network results in wasted energy and requires excessively strong cables and transformers. On a statistical basis, computers can calculate how many mechanisms are likely to require maximum power at any one moment and so permit economy in power network contruction and utilisation. The same statistical approach can be used for analysing the service which a repairman gives to automated machinery. Reliability statistics can be used to calculate not only how many machines one man can efficiently service on an automatic line, but also how many spare parts need to be brought to a warehouse at the beginning of each year in order to service the line, and even where the spare parts bins should be located to provide the most efficient service when breakdowns occur. This approach of 'service time' (the Danish scientist A. K. Erlang and the American engineer Shannon elaborated the fundamentals of the concept) can be used to analyse the service of passengers in transportation terminals and stores.[9] It also has obvious applications in military operations.

[8] See S. N. Braines, 'Nevrokibernetika', and A. D. Voskresenskii and A. I. Prokhorov, 'Problemy kibernetiki v meditsine', both in Berg, op. cit. An English translation of an article on the same subject is E. Khudiakova, 'Cybernetics and Medical Diagnosis', *The Soviet Review*, February 1961. During a recent trip to the Soviet Union a diagnostic machine was demonstrated to me by engineers of the Moscow Power Institute.

[9] V. A. Venikov, 'Primenenie kibernetiki v elektricheskikh sistemakh', and I. Ia. Aksenov, 'Transportnye problemy kibernetiki', in Berg, *op. cit.* There is, of course, an immense literature in many languages on these and other problems concerning the application of cybernetics.

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ONE difficult cybernetics problem noted by Soviet scientists is that of reliability. The cybernetic mechanisms with their controlling computers are so complex that even if each individual component has a very long average life, the reliability of the entire mechanism can be quite poor. The chance of one particular component failing is extremely low, but the probability of any one of thousands of components failing is always high. Several Soviet authors believe that the problem of reliability should be regarded as one that will be resolved only by evolution and natural selection. Over millions of years only those living organisms have survived which possess a high reliability in spite of their complexity. Since the construction of cybernetic machines has been going on only a few years, the selection of reliable mechanisms has hardly begun; the pace of the cybernetic revolution will be governed by the rate of this evolution. The disillusionment which many cyberneticists have experienced has often come not so much from their inability to construct machines with almost infinite possibilities of information storage as from their inability to operate them for any appreciable length of time.

Another important subject of study for Berg and his assistants is the problem of communication between man and machine. A man in charge of an automated process finds himself a link in a new sort of chain operation consisting of machine—computer controlling it—man. The computer is capable of thousands of operations per second, while the man's speed is much less. This presents him with an unusual problem: all the control operations he performs must be within his physical and psychological capabilities, even though many of the operations performed by the machine under his command are beyond those capabilities. This is virtually an admission that W. Ross Ashby had a point when he once remarked that computers may eventually become so complex that neither the men who constructed them nor the men who operated them would know why they do what they do.[10]

The application of cybernetics in the social sciences is particularly controversial in the Soviet Union, since the interpretation of society is, of course, a preserve of Marxist philosophy. But cybernetics can be used to elaborate Marxist theory, given sufficient willingness to make the attempt. Several Soviet writers have hinted that the withering away of the state can be interpreted as a cybernetic process, when society becomes 'cybernetic' or 'self-organising' and the traditional apparatus of state control becomes unnecessary. 'Without any doubt when society has been basically reconstructed . . . social self-regulation will become not only the predominant but the only possible process. At that wonderful moment cybernetics will have an incomparably broad field

[10] W. R. Ashby, 'Design for a Brain', *Electronic Engineering*, Vol. XX (No. 250), pp. 382–383. This view was sharply criticised by the Soviet author E. A. Arab-Ogly in 'Sotsiologiia i kibernetika', *Voprosy filosofii*, No. 5, 1958.

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At the Computing Centre of the Academy of Sciences

ON MONDAY, 14 OCTOBER 1963, WE VISITED the Computing Centre of the Academy of Sciences and had discussions with Academician Doroduizjin, the Director, and members of his staff.

The staff consists mostly of mathematicians, but also includes a small team of engineers who are responsible for maintaining the computers at the centre, making modifications to the computers, etc. The responsibilities of the centre cover the study of mathematical methods of computing, programming, the solving of specific problems using computers (in the field of science, including mechanics and physics, in the field of economics and business management), consulting work in the field of computers, and they also sell time on their computers to other organisations. They are concerned with the education of mathematicians for computing work, and in connection both with this work and their development of mathematical methods they have their own small publishing organisation for the printing and publishing of reports. This is a necessary part of their work in spreading the gospel about computing.

We were told that the work on language translation by computers was carried out at the Institute of Languages, and work on 'On-Line Computers', e.g. for control of production processes, was carried out at another institute—the Institute of Automation; neither of these subjects was studied at the Computing Centre.

We discussed for some time two current problems to understand the better their method of working. The first was an economic study of the possible increased production of crops by using increased quantities of fertilisers. It was noted that the average amount of fertiliser used at the present time was low compared with the amount currently used in the United Kingdom. This could therefore be increased with initially a correspondingly large increase in the production of the crops, probably up to a point where the rate of increase with increase of fertiliser had fallen to such a figure that, at this stage of the development of the USSR, it would be more economic to bring further land under cultivation. Obviously, this optimisation problem was closely connected with the geographic location of the land under consideration, the climate enjoyed, and other matters. It also had to take into account realistic estimates of the maximum supplies of fertilisers which could be made available. The results obtained would also depend markedly on the accuracy of the statistical information which had to be used as input data for the investigation.

The second question discussed was the transport of various consumable commodities into the shops, etc., of Moscow. Every Friday the various shops, depots, etc., transmit their requirements for the next week by land line via the Moscow transport centre, to the Computing Centre. The latter, knowing the concentrations required of these various commodities (they deal with upwards of 20 items at the present time), and the location of their various stockpiles, producing centres, etc., compute the optimal plan for transporting the goods to the required points. On

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the average this has resulted in a saving in transport costs of about 10 per cent., but in exceptional cases it has been up to 40 per cent. (It may be noted that J. Lyons & Co. started some years ago to use the 'Leo' computer to optimise handling of goods in the same way.)

In further discussion it was noted that the majority of applications of digital computers in the USSR at the present time are for research and design, but that application in business management and in economic studies is increasing.

Computers in use

THERE ARE THREE COMPUTERS in use at the Computing Centre. All are valve-operated and were designed some time ago. They are hoping to obtain a faster transistorised computer some time in 1964.

One of the most popular of the valve-operated computers in the USSR, and the first one to be seen at the Computing Centre, is the B.E.S.M.2. This uses a 2048 words ferrite core memory and the system is capable of operation at an average rate of 8,000–9,000 operations per second. The ferrite core memory is backed up by a magnetic tape memory and a magnetic drum memory. The input and output facilities appeared to be conventional, punched cards and high speed printers being seen. The computer appeared to be the main tool of the Centre and was giving good service within its limitations.

The second computer, designated Arrow, used a cathode ray tube memory, backed up with both magnetic tape and magnetic drums.

At the Exhibition of Economic Achievements we later saw a first example of a Russian transistorised digital computer. This is the DNIPRO, produced for use in business management, etc. It too uses a ferrite core memory with a capacity of 512 26-bit words and is backed up with a tape memory. The speed of operation is about 8,000 operations per second. Punched card input and high speed printer output are provided.

Future requirements

AS WE APPEARED TO BE GETTING NOWHERE as to the type of transistorised digital computer the Centre would have, we discussed their requirements as at present envisaged. The Director pointed out that a million operations per second was not sufficiently fast for the type of problem which they would like to tackle (including problems in modern physics and mathematics), and he would like to get as near as 10^9 operations per second as possible. The present equipment was not readily used for the solution of the increasing range of problems involving three or more independent variables. He also agreed that they wanted a very large memory store (100,000 words). It was noted that Academician Doroduizjin considered the British 'Atlas' computer good in respect of speed, but he thought that the capacity of the memory was insufficient.

He also stated that the peripheral equipment was especially important in their case, because their computer had to handle much economic data and telegraph lines; radio links input would also be required.

From an Unpublished Report by a Study Group of the Federation of British Industries

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of activity.'[11] This interpretation is a minority one in the Soviet Union, however, since it rephrases Marxism in the language of a new theory of social development, and even the writer of those lines admitted that cybernetics is limited as a tool of social analysis.

A less controversial application of cybernetics in the social sciences may be found in economics. Here cybernetics is said to be of far greater utility in the Soviet Union than in any capitalist country. Soviet analysts point out that Western cyberneticists themselves have noted the 'absence of purposefulness' in the development of Western economies and the consequent inapplicability of the cybernetic approach. The Soviet Union, however, has a national economic plan which supposedly provides the necessary national purpose. The most important economic application of cybernetics, according to the Soviet economist V. D. Belkin, is the control of the supply of products and raw materials to industrial enterprises. Previous attempts to plan the national economy have been severely hampered because an adjustment of supply quantities anywhere in the system causes unending corresponding adjustments elsewhere in the system, since almost all important products are interdependent. The use of computers will no doubt help in the attack on this problem. Belkin noted, however, that some Soviet economists resolutely oppose the use of cybernetics in economic planning. He considered this opposition 'intolerable'.[12] Another economist, A. I. Kitov, a partisan of cybernetics, called for the creation of a unified national system of computing centres for control of the economy.[13] Paradoxically, he drew most of his illustrations from the industrial use of computers in the United States.

ANOTHER application of cybernetics in a non-technological field is in education. Programmed learning and teaching machines are viewed in the Soviet Union as cybernetics in education. Teaching machines permit the student to check on his progress (to have feedback) at each stage of his development; some of the more sophisticated ones vary the questions given to students on the basis of their previous records. An outstanding student will be rapidly catapulted ahead in the lesson sequence, skipping certain sections, while a poor student may be forced to repeat lessons many times. Soviet educators have expressed a keen interest in several of the machines now being exhibited by the U.S. Office of Education, especially machines for teaching foreign languages, which are capable of speaking to the student, correcting his pronunciation, and regulating his progress.

11 V. N. Kolbanovskii, 'O nekotorykh spornykh voprosakh kibernetiki', in Ilin et al., op. cit., p. 248.

12 V. D. Belkin, 'Kibernetika i ekonomika', in Berg, op. cit., 188. The opposition to cybernetics is connected with the opposition to econometrics. See S. M. Shaliutin, 'O kibernetike i sfere ee primeneniia', in Ilin et al., op. cit., p. 55.

13 A. I. Kitov, 'Kibernetika i ekonomika', in Berg, op. cit. A discussion in English of a cybernetic model of a centrally planned economy devised by the Polish Academy of Sciences Econometric Commission may be found in Henryk Greniewski, *Cybernetics Without Mathematics* (Warsaw, 1960), p. 196.

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Other applications of cybernetics in non-technological fields in which the Soviet Union is interested are quite well known in the West. The mechanical translation of languages is a subject of study in many countries. The use of computers for surveying immense bodies of legislation or national statistics so that lawyers or statisticians can find vital facts, legal precedents, or discern the need for new laws, as well as find conflicts with old ones, is also a problem of information retrieval which Western engineers and jurists have often contemplated.[14]

Soviet cyberneticists have also applied cybernetics in the sciences themselves. Weather prediction, for example, can be facilitated by the use of computers. (The Washington Weather Bureau has had a computing centre for many years.) Somewhat more novel is the use of computers in organic chemistry. Soviet engineers are working on computers which will translate the familiar structural formulas of chemical compounds into a machine language, a linear sequence of symbols. By using the new symbolic language, machines can be utilised to suggest optimum means of synthesising new organic compounds. The machines will be ' self-teaching ' and can improve their ' knowledge ' of structural chemistry on the basis of past experience. The need for computers in chemistry is illustrated by the fact that there are over a million chemical compounds which have been described in chemical literature and many millions of different chemical reactions.

These examples of the application of cybernetics give a sketchy outline of Soviet interest in this field. A notable gap is the utilisation of computers in planning military operations, a subject not covered by Academician Berg in his surveys. The statistical approach to service time and priority, the computation of optimum transportation methods, and the assignment of effectiveness and reliability ratios can all be applied to military planning. Several Soviet authors have criticised the utilisation of computers in military planning on the ground that these calculations do not take sufficient account of morale and national pride, but there is no doubt that the Soviet Union is pursuing research in this area.[15]

THE Soviet Union has clearly enrolled itself as a participant in the cybernetic revolution. But what of the original objections? If cybernetics was once seen as a competitor with Marxism, is it not still? If the belief that machines can duplicate life processes was once a ' step backward two hundred years ', how should a Soviet scientist regard those

[14] For a Soviet article in this field, see N. D. Andreyev and D. A. Kerimov, ' Vozmozhnosti ispolzovaniia kiberneticheskoi tekhniki pri reshenii nekotorykh pravovykh problem ', in Berg, op. cit., 234–241. A superior discussion of some of the same problems can be found in Lucien Mehl, ' Les sciences juridiques devant l'automation ', *Cybernetica*, Nos. 1 and 2, 1960.

[15] A sceptical Soviet view of the use of cybernetics in military planning may be found in B. S. Ukraintsev, ' O vozmozhnostiakh kibernetiki v svete svoistva otobrazheniia materii ', in Ilin et al., op. cit.

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The State Committees for Radio Electronics and Electronics Techniques

WE HAD A SINGLE meeting with the two Committees jointly on Thursday morning (10 October). It was noted that the second committee was necessary because of the specialist nature of the work on electronic components, e.g. resistors, capacitors, etc., and active elements such as thermionic valves, diodes, and transistors, and it was found that this division of responsibilities worked well, although it was noted from later questions that the Committee had not yet been very active in the 'integrated circuit' field.

The State Committee for Radio Electronics was responsible for ensuring that the problems were tackled at the right technical level and with the necessary support and that duplication was avoided. Apparently this is easy to do because the bulk of the finances for the various programmes is controlled directly by the State Committee, and if some work is *not* required, the finances are not forthcoming! If work needs to be accelerated or reinforced larger financial resources are provided, and, as necessary, further institutes brought in to work on selected parts of the problem. It was noted that when this was necessary, one institute was nominated the 'head institute' and was responsible for the whole programme. Finance was also provided by the Academy of Sciences for some of the more fundamental studies, and, as far as possible, duplication and proper exploitation of ideas was engendered by arranging where necessary common membership of committees and good communication of information. It was noted that there were various categories of work, viz: (i) speculative, (ii) research, (iii) development leading to an experimental prototype, (iv) preproduction, leading to a production prototype (in some cases a pilot plant would be involved), (v) large-scale production.

It was noted that according to the nature of the job, a 2-year, 5-year, or even 7-year programme may be involved. The plans are discussed at the State Committees, and as necessary probed at the institutions concerned. At this stage the Committee tries to avoid getting involved in too much science, but ensures that the objectives are clearly understood. In the early stages of the work the scientists alone are involved, but as it progresses engineers will be attached to the project, perhaps from the factory which will later be responsible for the manufacture of the particular product. At a later stage, when the project moves to the factory, the scientist may move with the job for a time to assist the engineers. In some cases the scientists will simply visit the factory for consultation at various stages. It was noted that there are various incentive schemes to ensure that the scientist continues to take an interest. Thus, we were told that in some cases a bonus was payable to the institute (shared by the members of staff in proportion to the size of their wage packets) on the following basis: 40 per cent payable when the first model is approved; 60 per cent payable when the product goes into mass production.

From an Unpublished Report by a Study Group of the Federation of British Industries

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machines today? Soviet philosophers have continued to ponder these questions.

The universality of the application of cybernetics was one of the first aspects of this new science to alarm the Marxists. Cybernetics displayed ambitions towards becoming a philosophy of both the natural sciences and the social sciences. Almost all complicated dynamic systems can be described in terms of cybernetic components regulating themselves on the basis of feedback information. Whether this system is an automatic airplane pilot, the human body, or an organisation of individuals in a town government is one and the same to convinced cyberneticists. Even Wiener, who was more cautious than some of his disciples, agreed that cybernetic analysis could be applied to human society; he believed that the controlling mechanism of society is its legal system, and that society constantly adjusts its laws on the basis of feedback information concerning the degree of disorder in society.[16] Ashby regarded society as a system with ' homeostatic properties '. The homeostat is a random mechanism capable of adapting itself to its environment in such a way that it arrives at equilibrium and appears to be ' purposeful '.[17] Others have begun to use the cybernetic approach to sociology, history, and public administration.

Soviet Marxism is, of course, a total philosophy, embracing both a philosophy of history and a philosophy of science. If one believes in the existence of absolute truth, as dialectical materialists do (although Engels once said man's approach to that truth could be no more than asymptotic), then one must believe that two different philosophies aspiring to universalism cannot be equally true. Soviet philosophers saw cybernetics as a competitor of the dialectic. As one Russian scholar put it:

> The subject of cybernetics is organic and inorganic nature (and technology), social processes and phenomena concerned with consciousness . . . But doesn't this mean that cybernetics opposes [Marxist] dialectics, that it is attempting to take its place as a new ideology? If such is the case . . . then the question would be: either dialectics or cybernetics . . . The attempts to convert cybernetics into some universal philosophical science are completely baseless. Marxists must reject them out of hand.[18]

Cybernetics became a topic of philosophical dispute in the Soviet Union at a time when the Marxist dialectic possessed few active defenders. During and shortly after Stalin's lifetime Soviet philosophers and

[16] Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (New York, 1954), pp. 105–111.

[17] See W. Ross Ashby, *An Introduction to Cybernetics* (London, 1956), pp. 83–85, 270–271; and Kolbanovskii, ' O nekotorykh spornykh voprosakh kibernetiki ', 257–258. A general Soviet criticism of Western sociologists ' use of cybernetics is Arab-Ogly, op. cit. Another more specific criticism of a cybernetic interpretation of history is I. Ia. Aksenov, ' O vtorom mezhdunarodnom kongresse po kibernetike ', in Ilin et al., op. cit., p. 367.

[18] Shaliutin, loc. cit., pp. 25–27.

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historians had attempted to discern the operation of the dialectical laws in almost every field of research, from chemistry to history. In recent years, however, the dialectic has attracted less and less attention: revisionist philosophers in Eastern Europe and elsewhere have rejected the use of the dialectic in interpreting scientific theories.

Cybernetics is much more disciplined in its approach.[19] Indeed, cybernetic analysis has already permitted an occasional prediction, whereas the success of the dialectic as a guide to research has been abysmal; no practising scientist even in the Soviet Union would think of predicting results on the basis of the dialectic. In the very first years of their research on feedback mechanisms, however, Wiener and Julian Bigelow arrived at the hypothesis, from their work on fire-control systems, that human beings probably displayed pathological symptoms similar to the occasional uncontrollable oscillations of their gun mounts. Dr. Arturo Rosenblueth, then of the Harvard Medical School, quickly confirmed their hypothesis: the pathological condition is known as purpose tremor, and is a result of the excessive feedback which troubled Wiener's and Bigelow's mechanisms.[20]

Soviet thinkers have been able to defend the legitimacy of cybernetics despite its alleged incompatibility with Marxism by placing the two on entirely different planes. According to the interpretation now becoming fashionable, cybernetics and Marxism do not study the same phenomena and do not try to perform the same functions: Marxism is the science of the broadest laws of nature, society, and thought. Cybernetics, on the other hand, is a science only of systems of control and communication. Therefore, Marxism is so much broader, so much more general than cybernetics that the two do not conflict. 'The entire objective world', Shaliutin writes, 'develops according to the laws of the dialectic . . . Cybernetics, in contrast, . . . studies the laws of only those objects which make up control systems.'[21] Kolman notes that Soviet scholars are not alone in questioning the ambitions of cybernetics. Louis de Broglie, respected in the Soviet Union for his attempts to find causality in quantum mechanics, criticised the tendency of cybernetics to subordinate other disciplines to itself, especially psychology and sociology.

ANOTHER aspect of cybernetics which has been troublesome to Soviet theorists is the concept of 'information'. Cybernetics is based on the collection, refinement, and transmission of information. Indeed, the utilisation of information is the most characteristic property of a cybernetic mechanism. Yet no truly satisfactory definition of information has been devised, and a number of the definitions proposed by Western

[19] An attempt to restrict some of the claims of cybernetics can be found in Rajko Tomovic, 'Limitations of Cybernetics', *Cybernetica*, No. 3, 1959.
[20] Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine* (New York, 1948), p. 15.
[21] Shaliutin, loc. cit., pp. 25–26.

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cyberneticists have met with ideological objections in the Soviet Union. According to Wiener, ' information is neither matter nor energy ', it is just ' information '.[22] Dialectical materialism asserts that nothing exists except matter in various forms of motion. If information is neither matter nor energy, then what is it? Ashby gave warning of the dangers of trying to treat information as an individual ' thing ': ' Any attempt to treat variety or information as a thing that can exist in another thing is likely to lead to difficult " problems " that should never have arisen.' [23]

The need for dialectical materialists to define information in terms of objective reality becomes even clearer if one remembers that much of the most important work in cybernetics in recent years has been the effort to measure information quantitatively. The attempts to quantify information have not been halted by the lack of any universally accepted definition of what is being measured. This disregard for definitions, or at least delay in devising definitions, has led Soviet philosophers to accuse Western cyberneticists of making a fetish of information, of attributing to it non-materialist properties.

The accepted method of measuring information is by means of probability statistics, and the mathematical formulations are similar to those employed in the computation of thermodynamic entropy. The analogy between information and entropy (or, to be more precise, negentropy) has often been noticed. As early as 1927 R. V. L. Hartley observed that the amount of information conveyed in any message is proportional to the number of possibilities which are excluded by the message. Thus, the phrase ' Apples are red ' carries much more information than the phrase ' Fruits are red ' or ' Apples are coloured ', because the first phrase eliminates all kinds of fruits other than apples and all kinds of colours other than red. This exclusion of other possibilities increases informational content.[24] In recent years the basic principle enunciated by Hartley has been refined and elaborated until it received a mathematical basis. In 1949, in the signal publication *The Mathematical Theory of Communication*, Claude Shannon and Warren Weaver presented a formula for the calculation of quantity of information in which information increases as probability of the particular message decreases. Shannon's and Weaver's formula was similar to the well-known expression for thermodynamic entropy devised by Max Planck at the beginning of the present century.[25] Thus, cyberneticists faced the challenging and

22 One Soviet author came to Wiener's defence on the question of the nature of information, correctly noting that Wiener never intended to define information as a *non-material substance, but simply preferred to leave it undefined.* See F. P. Tarasenko, ' K opredeleniiu poniatiia " informatsiia " v kibernetike,' *Voprosy filosofii*, No. 4, 1963.

23 W. Ross Ashby, *An Introduction to Cybernetics*, p. 152.

24 Hartley's ideas were presented at the International Congress of Telegraphy and Telephony at Lake Como in September 1927, and published as ' Transmission of Information ', *The Bell System Technical Journal*, Vol. VII (1928), pp. 535–563.

25 Planck described his formulation of this relationship in his *Scientific Autobiography and Other Papers* (New York, 1949), pp. 40–42.

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extremely controversial possibility of unifying several quite diverse fields with similar mathematical tools.

The possibility of an analogy or even a structural identity between entropy and information generated a heated debate among physicists, philosophers, and engineers which is still proceeding, both in the West and in the communist bloc. Louis de Broglie called the link between entropy and information 'the most important and attractive of the ideas advanced by cybernetics'.[26] But for every enthusiast who might attempt to identify information with neg-entropy another sober-minded individual added a cautionary note. Ashby, for example, commented: 'Moving in these regions is like moving in a jungle full of pitfalls. Those who know most about the subject are usually the most cautious in speaking about it.'[27] And yet, despite the warnings, the general trend among cyberneticists has been a greater and greater acceptance of the conception that there exists some essential link between entropy and information, and that the quantitative concepts of thermodynamics can eventually be applied to many of those diverse fields in which cybernetics is already a useful approach.

In the face of such developments, the task of Soviet philosophers has been to define cybernetic information in such a way that it conveniently fits into the concepts of dialectical materialism. The ideologist who has most energetically undertaken this task is a newcomer to the field of Soviet philosophy of science, I. B. Novik; in his recent book, *Cybernetics: Philosophical and Sociological Problems*, he attempts to present a systematic treatment of cybernetics from the standpoint of enlightened Marxism.[28] From the outset he aligns himself with the partisans of cybernetics, although he insists that there is no conflict between this new burgeoning field of science and dialectical materialism. (He even describes Wiener as an unconscious dialectician.) Novik explains that cybernetic information is a property of matter, a property directly connected with Lenin's copy-theory of epistemology. Lenin wrote in *Materialism and Empirio-Criticism* that materialism is based on a recognition of 'objects in themselves', and that objects exist 'without the mind'. According to him, ideas and sensations are reflections of these objects; all matter has this property of 'reflection'. Novik then postulates that 'quantity of information' is a measure of the order of the reflection of matter. 'In my opinion', he writes (p. 60), 'in information, and especially in the structure of its symbols, is expressed the order of reflection . . . In this sense, noise is connected with disordered, chaotic reflection.' Novik then calls for the creation of a science of the 'physics of reflection', and in order to hasten the development of this new field he proposes a rudimentary law of the conservation of

[26] Louis de Broglie, 'La Cybernétique', *La Nouvelle Nouvelle Revue Française*, July 1953, p. 85.

[27] Ashby, *An Introduction to Cybernetics*, p. 177.

[28] I. Novik, *Kibernetika: filosofskie i sotsiologicheskie problemy* (Moscow, 1963).

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information patterned on the law of conservation of matter, since information is 'inseparably linked' to matter (p. 58).

THE most frequently discussed issue of cybernetics concerns the belief of some cyberneticists that their machines will eventually duplicate life processes. To narrow all the controversies of cybernetics down to the one question 'Can a machine think?', as some popularisers have done, is to impoverish the intellectual content of the recent discussions of cybernetics. Nevertheless, the question certainly has been seriously considered by most cyberneticists, and it has played an important role in the discussions in the Soviet Union. Wiener himself was properly cautious on this issue, but even he felt that some new definition of 'life' may be necessary. He noted that living organisms and inorganic cybernetic systems are similar in that they are both islands of decreasing entropy (disorder) in a world in which disorder always tends to increase. He observed that 'the problem as to whether the machine is alive or not is, for our purposes, semantic and we are at liberty to answer it one way or the other as best suits our convenience'.[29] On another occasion he remarked that whether or not a machine can think is merely a 'question of definition'. The English logician A. M. Turing was much more willing to face the possibility of thinking machines. He believed that a machine could be considered to think if a man separated from a machine by an opaque partition could not determine whether he was facing a machine or another man, basing his conclusions on the answers which he received to questions addressed to the machine.[30]

Soviet philosophers and scientists have no agreed interpretation of cybernetics, but with a few notable exceptions they have stood fast in their belief that the celebrated problem of whether or not a machine can think must be answered negatively; it is not, as Wiener believed, a question of definition. To attribute mental powers to a mechanical agglomeration of transistors and circuits would be, they say, to make the mechanistic mistake of believing that all complex operations can be reduced to combinations of simple ones, a belief specifically denied by their interpretation of dialectical materialism. They maintain that sophisticated organisms differ qualitatively from less complex ones, and cannot be reduced to the same components. Academician Berg agrees that machines exceed the mental capacity of human beings in certain restricted functions, such as memory and calculation, but asks: 'Does this mean that electronic machines "think"? I am certain that they do not. Machines do not think and they never will think'.[31]

The relationship of cybernetic machines to man is also important in a broader moral sense. On the whole, Western cyberneticists are more fearful, at least publicly, of the possible results of their research than Soviet scientists. Wiener told a group of Soviet philosophers:

[29] Wiener, *The Human Use of Human Beings*, p. 32.
[30] A. M. Turing, 'Computing Machinery and Intelligence', *Mind*, Vol. LIX (October 1950), p. 434.
[31] A. I. Berg, 'Nauka velichaishikh vozmozhnostei, *Priroda*, July 1962, p. 21.

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> If we create a machine . . . which is so 'intelligent' that in some degree it surpasses man, we cannot make it altogether 'obedient'. Control over such machines may be very incomplete . . . they might even become dangerous, for it would be an illusion to assume that the danger is eliminated simply because *we* press the button. Human beings, of course, can press the button and stop the machines. But to the extent that we do not control all the processes which occur in the machine it is quite possible that we will not know when the button should be pressed. Thus, the programming of 'thinking' machines presents us with a moral problem.[32]

Other Western cyberneticists have spoken of a dictator controlling society through the use of cybernetic machines, while still others have referred to the computer as the demon which might overthrow its master.

All these pessimistic views are denied by Soviet writers. The role of man, they say, will not be diminished by the machine but increased. Indeed, Kolman defines the difference between man and machine by the fact that only man can determine goals, while the machine performs only the role it is assigned.[33] If society sets worthwhile goals, the machine will perform worthwhile functions. It is suggested that Western cyberneticists may be revealing their lack of confidence in their own societies when they doubt the roles their computers will be asked to perform.

Although Soviet ideologists have maintained that cybernetics has very different functions in different economic systems, one conclusion which can be drawn from the controversy over cybernetics is that this new field of science has provoked spirited discussions everywhere. Many of the questions concerning cybernetics which have attracted attention in the Soviet Union (Can machines think? Can cybernetics be employed as a method of sociological analysis?) have also been at the centre of controversy in the West. Cybernetics is one of the most important conceptual schemes to develop in science since the war, and the discussions surrounding it can be compared only to those over relativity physics and quantum mechanics in past years. At the root of the questions which have troubled the Soviet ideologists are legitimate intellectual issues. The Party continues to shoulder ultimate responsibility for the philosophical interpretations of science, but the latitude of discussion is great enough to permit debates of considerable interest to Western observers.

[32] 'Norbert Viner v redaktsii nashego zhurnala', *Voprosy filosofii*, No. 9, 1960, p. 164.
[33] E. Kolman, 'O filosofskikh i sotsialnykh problemakh kibernetiki', loc. cit., p. 95.

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THE ORGANISATION OF SCIENTIFIC RESEARCH

D. A. Senior

THE Soviet government takes the view that scientific research and development should be planned as a whole and integrated closely with the state's economic plan. One of the difficulties, however, in the Soviet Union as elsewhere, is that of persuading the scientists to keep to the plan when they so readily turn aside to follow their own interests. In a Marxist society, moreover, there is need for 'philosophical guidance'; scientists can be very 'unreliable'.

Then there is the problem of deciding what job of work should be given to each scientist in the first place, whilst making sure that none of them is duplicating the work of someone else, for research is costly. Of course it may turn out in the end that the work a scientist has chosen to pursue is more useful than the work which has been given to him. But on the other hand it may not; he may well become involved, as one Soviet scientist did (so incurring Mr Khrushchev's personal displeasure), with a subject such as the black storks of Transylvania. With technologists the tendency to err is not so great. They are generally more interested in solving problems than in making discoveries; so it is an easier matter to ensure that they keep their minds on their work. But there is still the problem of duplication of effort (it is so much more enjoyable to do experiments than to read about them).

In other words, from the planner's viewpoint, science is evidently a nightmare. If you give a scientist a job to do and a line of thought to follow it is quite likely that he will end up doing something entirely different and adopting a point of view which is the opposite of the one he was intended to accept. And he is always wanting more money.

There are then several inter-related problems facing the Soviet planner of science and technology, some of which are also of concern in the West. Let us look at the first of them—in Soviet terms, the problem of strengthening the ties between science and production. It is well illustrated by the history of the All-Union Academy of Sciences, which is the most important scientific body in the country, akin to the Royal Society, but it is responsible in addition for about a hundred research institutes.

The Academy was founded in 1724 by command of Peter the Great as the St. Petersburg Academy of Sciences. It was given duties on an ambitious scale, many of which it inevitably failed to carry out: it was expected to do scientific research of a high order, to solve practical problems, to act as an advisory service to the government, and to organise the country's higher and secondary education. In 1747 the Academy was divided into two parts—the Academy proper and the

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University—so that it shed its responsibilities for education. It is interesting that the statute bringing about this division stipulated that the Academy should inform the government at the beginning of each year of the problems it planned to study and made it mandatory for academicians to work on special requests emanating from various government agencies.

Fifty years later another statute established special departments for the social sciences—history, economics, political sciences, and oriental studies. The statute reiterated the obligation of the Academy to direct its work towards practical tasks but the members tended to devote their energies to the advancement of knowledge for its own sake or for their own amusement. The statute of 1836 recognised this tendency, relieved the academicians of certain teaching duties, and proclaimed the Academy to be the primary scientific body of the Russian empire. The Academy was merged in 1841 with the Imperial Russian Academy and so acquired responsibilities for the study of language and literature. It was now divided into three departments; the department of Physico-Mathematical Sciences, the department of Russian Language and Literature, and the department of Historical and Political Sciences and Philology—all scientific subjects in the *wissenschaft* sense.

During the early 19th century the Academy began to lose its overall grip on Russian science. It was challenged and even out-distanced in certain fields by new societies such as the Moscow Society for the Study of Nature. But at the end of the century the pre-eminence of the Academy in Russian science was fully re-established and it was no longer challenged.

The first world war saw the Academy devoting significant effort to practical problems for the first time. A commission was set up to study the country's natural resources and to assume the task of working out an inventory of the country's riches. It was called upon to study in detail 'the inadequately investigated problems relevant to the national economy', to organise and to coordinate the work of the research institutes, and to take the lead in training technological personnel.

FOLLOWING the revolution of October 1917 the Academy was increasingly urged to organise its work in such a manner as to tie in with the government's economic plans. Lenin in 1919 summed up the basic tasks: to organise committees of specialists who would 'draw up a plan for the reorganisation of industry including the rational merging of production into a small number of large enterprises; and to create maximum facilities by which the Russian Soviet Republic could support itself independently with all the main types of raw material and industry, centring special attention on the electrification of industry and the utilisation of other sources of power'. But the Academy strayed back to the study of pure science. In 1930 a new statute was promulgated which stressed the principle of practical usefulness as a chief criterion in appraising scientific research, and it sanctioned the regrouping of the

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Academy's research units into larger institutes and the creation of purely technical research units. In 1934 the Academy was moved from Leningrad to Moscow and in 1935 a new statute was passed which emphasised the paramount role of the Academy in paving the way for the full establishment of a new socialist classless society. The new statute added a technical department to the existing departments of the Academy.

In 1936 the emphasis was shifted from individual research to complex research projects calling for participation of many scientists; Krizhanovsky, the Vice-President of the Academy, specified ten leading economic problems requiring complex theoretical research and field-work on the part of the Academy's institutes—the germ of the idea of the basic directions of science which features in today's planning. In 1937 the three departments were reorganised into eight and the Academy widened its scientific horizons to include virtually all fields of knowledge.

During the second world war, the Academy's institutes were engaged on military problems and working under great difficulties. Immediately after the war, Stalin placed before Soviet science the task of reaching and surpassing in the nearest future the scientific achievements outside the Soviet Union, and there was a period of intense 'scientific nationalism' (which gave rise to the 'Russian invention' stories and the absurdities of 'anti-cosmopolitanism'). In 1949 there began a campaign to strengthen the planning of scientific productivity and to eliminate the 'useless' forms of science which were creeping back into the Academy's work. Various measures were enacted to ensure that the Academy concentrated on practical work and by the early 1950s the department of Technical Sciences had more academicians than the three departments for social sciences and humanities combined. The call for a 'strengthening of the ties between science and production' became more insistent, and pure scientific research became more difficult in the face of an intensive campaign to subordinate everything to the plan.

Stalin died in 1953, and the Academy began to revive as a seat of learning; contact between Soviet and foreign scientists was resumed and there was a re-emphasis on fundamental investigation.

By 1959 the structure of the Academy was in need of reorganisation to meet the changed circumstances. Work was concentrated in research institutes in Moscow and Leningrad. Lack of co-ordination of effort had led to the study of identical problems by different institutions (parallelism), and it was said that the Academy had failed to weed out people who no longer possessed or never had possessed ability. Above all, there was the vexed question of the department of Technical Sciences which had grown enormously and was no longer in key with the Academy in its new role, or resumed former role, as the home of fundamental scientific research.

The problem of over-centralisation had been tackled in the economic sphere in 1957 by the abolition of some thirty specialised All-Union ministries responsible for the production of such materials as oil, chemicals, etc., and the creation of about a hundred regional economic

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Science in Two Worlds

. . . THE UNITED STATES IS STRONG in pure science, and our leadership, at least in the discipline with which I am most familiar, that is, physics, has not been effectively challenged. This cannot be said of the applied, or 'mission-oriented', sciences, especially in their military applications. In these fields, the USSR does not seem to be lagging behind the USA, and is ahead of us in many respects.

It is tempting to speculate on the reasons for this situation, and whether it should, and if so how it could, be remedied. Before doing this, it may be well to say a few words on the distinction between pure and applied science, and to support the thesis that United States strength in pure science is not paralleled by equal strength in the applied field.

Pure science is the endeavour to become acquainted with the laws of nature. Mission-oriented science and technology are efforts to increase our power and ability to do something. The difference between the two is, therefore, principally in the objective of the effort. But this is not all. The whole spirit of the endeavour is different, depending on whether one wants to know, for instance, the laws of gravitation or wants to construct a machine which abolishes gravitation in a certain area. Nevertheless, as this example shows, the two endeavours cannot be sharply separated.

As to pure science, the following list of the most important experimental and theoretical discoveries since the end of the second World War may be illustrative:

Experimental discoveries	Theoretical work
United States	
Lamb shift and the electron's magnetic moment	Renormalisation
Masers and Lasers	Nuclear shell model
Mesons, baryons, and high energy resonances	Explanation of superconductivity
Size and shape of nuclei	Strangeness and the SU_3 model
Parity non-conservation	
Transistors	Dispersion relations
Van Allen layer	A-V interaction and the conserved current
New accelerators	Progress in many-body problems
New superconductors and quantised flux	
Bubble chamber	
Elsewhere	
Exploitation of pinch effect	Collective model of nuclei
Mössbauer effect	TCP theorem
Solid state detectors	Progress in many-body problems
Quantised flux in superconductors	SU_3 model
Soviet Union	
Cerenkov radiation	Theory of superfluidity
Second sound in He	Analysis of general relativity
New accelerators	Lepton conservation

Even allowing for a certain bias in this writer—which he has tried to compensate for but perhaps not adequately—it is evident that the position of the USA in pure science is very strong. The list shows 17 entries for the United States, 6 for the Soviet Union, and 8 for the rest of Europe. It is important to realise, however, that the past is never a measure of the future and *the situation may change any day.* It is also important to realise that the list refers only to physics—even in mathematics, the

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list of the most important discoveries would not be weighted so heavily in our favour. However, in pure physics and at the present time, there is not much cause for alarm. American science is vigorous and is, on the whole, successful.

The situation is much less favourable in technology and applied physics, in particular in military applications. It does not seem that the USSR is lagging behind the USA very much in these fields, and it is ahead of us in many regards. The first sputnik is still vividly in our memory and some believe—and some Russians claim—that they were the first to explode a hydrogen bomb.

IT IS NATURAL TO ASK WHETHER American strength in fundamental science, and Russian strength in applied science, are somehow results of the two social systems. It is obviously impossible to answer this question categorically. Nevertheless, there are elements in our system of government which favour the flowering of pure science, and there are elements in the communist system which support applied science more strongly.

Not that the government of the Soviet Union does not support science vigorously. Soviet doctrine has been modified and now includes the principle that science has become a productive force. Expenditure on science has multiplied in the Soviet Union since the war, and so has the number of scientists and of scientific institutions, not only in the Soviet Union itself but also in the countries of the Soviet bloc. Will the balance between pure and applied science shift as a result of these moves towards more pure science in the Soviet Union?

It is of course quite possible that the Soviet Union will excel all other nations in pure science, and that this will happen in the near future. However, whether this will have much to do with the Soviet recognition of science as a direct productive force remains doubtful. After all, it is applied science and technology which is the *direct* productive force; pure science is at best an indirect means to production.

Nevertheless, it would be irresponsible to be complacent on this score. We have seen, in the past years, that communist doctrine can be so modified that it does not greatly interfere with the understanding of modern physics by large numbers of able young Russian physicists. It is possible also that we, the scientists of the democratic countries, over-emphasise the importance of freedom for the progress of science. We may recall that absolute freedom not only of thought but of publication was widely claimed after the war to be a necessity for successful work in pure *and* in applied science. The Russian success in applied science, achieved in complete secrecy, exploded this doctrine. Nevertheless, it is perhaps more than a comforting thought that the sense of freedom fosters the higher flights of the imagination.

Some of the causes of our strength in basic science are perhaps also the sources of our weakness in the applied sciences. Our best people are diverted from the applied field, and it is not easy, though by no means impossible, to find a first-rate scientist working in an applied physics laboratory.

Eugene P. Wigner

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councils or Sovnarkhozy, each of which was responsible for most of the production within its area. In the scientific sphere, the chosen answer was to build up the institutes in the republics and the 'filials' of the Academy, and to move institutes out from Moscow and Leningrad.

THE story so far has concerned itself entirely with this All-Union Academy, since it is the oldest, largest, and most important of the academies. It is at the same time the Academy of the RSFSR and has about ten 'filials' in various parts of the Federation, including an important one at the new scientific town of Novosibirsk. In addition, each of the other fourteen republics has its own academy. Some of these are large and have high standing, such as that of the Ukrainian Republic, while some are just starting. The Moldavian Academy, for example, is only a few years old. There are also All-Union Academies of Medical Sciences (founded 1944), Agricultural Sciences (founded 1929), and Construction and Architecture (founded 1955). Some of the republics have also academies of agricultural sciences, construction and architecture, and so on.

Decentralisation of scientific effort would obviously increase the problem of co-ordination to eliminate parallelism. Economic decentralisation had been accompanied by the setting up of State Committees to secure the links between industry and the central government. These are not committees in our sense of the word; they have permanent staff in large numbers and aim to provide a better technical foundation for the work of Gosplan, the body responsible for the state economic plan. In the scientific context central control was retained through the presidium of the All-Union Academy, which prepared a list of thirty 'basic directions' of science, twenty-three of which were scientific according to our definition. It was proposed to create scientific councils for each basic direction in which scientific research, planning and construction organisations would be represented, and to appoint a 'Head Institute' to lead work in each direction.

This was early in 1959. Shortly afterwards, Khrushchev said in a speech to the plenum of the central committee of the Communist Party that the performance of the Academy was inadequate and its organisation must be recast. In the ensuing discussion Academician N. N. Semenov [1] suggested that the number of departments be reduced from eight to three, that half the research workers should enter the Academy for a probationary period of three years, only 10 to 15 per cent of these being retained, that younger men should be appointed to the leading scientific posts (to clear out the dead wood and improve standards all round), and, most important of all, that the institutes of the department of Technical Sciences should be removed and put under the control of Gosplan. The article caused a great stir and was followed by several articles in *Izvestia* and *Literaturnaya Gazeta*. Semenov eventually withdrew his first

[1] 'Science Today and Tomorrow', *Izvestia*, 9 August 1959.

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proposal about reducing the number of departments of the Academy but defended the second against such opponents as Academicians Blagonravov and Bardin; their main concern, they said, was that the work of the Academy should not be divorced from practical experience. The proposal was made that the technical institutes of the Academy should be placed under the control of the Regional Economic Councils, instead of Gosplan, but this, it was argued, would be even worse, since not only would the contact between science and technology be impaired, but results would be 'regionalised'. Suggestions were put forward that there should be separate academies of technical sciences, physics, chemistry, etc., but this was opposed by Semenov and others, who pointed out that many problems lay on the borderline between two or more subjects and that segregation would act as a brake on the development of research.

Academician Bardin, who was head of the department of Technical Sciences, took the view that, since technical progress was primarily due to the fertilising effect on technology of the latest achievements of physics and chemistry, bridges must be built between these subjects. These could best be built by institutes of technical sciences within the Academy. This was in fact Semenov's answer to those who would have set up separate academies of chemistry, physics, etc., but he did not believe that the argument could be applied to technical subjects.

Though wishing to retain the Technical Sciences department within the Academy, Bardin was critical of the Academy as it was. 'The main trouble with the Academy of Sciences', he said, 'is that it turns research workers into office managers.' Academician Mints suggested that a special council be set up consisting of a small number of outstanding scientists who had the gift of scientific foresight and 'who had proved by deeds their ability to advance and support new ideas, long before the benefit from these ideas became obvious'. This proposal for a scientific collective oracle on the lines of Lefebre's Council of Newton did not, however, receive any support.

The basic requirement was expressed by Bakulev: 'The correct organisation of scientific research, its planning and co-ordination, the correct selection of personnel and high technical standards are the major conditions for the fruitful development of science'—which was true but not very helpful.

AT the 1960 Annual Meeting of the Academy of Sciences the President, Academician Nesmeyanov, gave the Academy's verdict about the Technical Sciences department. He stated that the significance of this division was much wider than that of the institutes which comprised it, since it was the most authoritative college of scientist-engineers on whose shoulders rested a considerable part of the responsibility for the technical progress of the country. The Technical Sciences department was to be retained within the Academy, but its efforts were to be concentrated more on fields which were likely to revolutionise technology, such

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as automation and remote control, radio technology, and new sources of power. In the meantime proposals were being worked out for improving the work of the Academy and for co-ordinating the scientific effort of the country. The aim, he said, was to co-ordinate scientific work in the whole of the Soviet Union (inside and outside the Academy) into one ' scientific organism ' which would play its part in the building of communism—to change the metaphor, an orchestra with the Academy as its conductor.

There was no further news for over twelve months. Then, on 12 April 1961, a joint resolution of the central committee of the Communist Party and the USSR Council of Ministers was published. Co-ordination of Soviet science was to be entrusted to a newly formed (All-Union) State Committee for the Co-ordination of Scientific Research, whilst the Academy was to be freed from certain tasks so that it might concentrate its energies. A number of the Academy's research institutes and establishments were to be placed under the control of state committees and ministries of the Council of Ministers of the Russian Republic.

The President of the Academy resigned about a month later and was succeeded by Academician M. V. Keldysh, who took the opportunity of the All-Union Convention of Scientific Workers (June 1961) to voice some opinions on the co-ordination of research and the work of the Academy. He gave many examples of duplication of effort. No fewer than one hundred bodies, he said, were engaged on the problem of direct conversion of heat energy into electric power. Delays in the introduction of scientific achievements into production were largely due to the absence of unified planning and co-ordination of the work of the research institutes, design bureaux and industry. About one half of the Academy's institutes would be transferred to industry, whilst in the remainder work of minor importance would be eliminated. He pointed out that the new arrangement in no way diminished the importance of scientific work. It was necessary, he said, that technologies should develop faster than heavy industry and that the natural sciences forming the fundamental basis of technological progress should outstrip the rate of development of technology. Scientific work should thus have the highest priority, its planning being integrated closely with the State Economic Plan. It was of prime importance to determine which were the leading problems (or basic directions), and one of the most important forms of co-ordination would be the scientific councils for these basic directions.

Winding up the proceedings A. N. Kosygin, first deputy chairman of the Council of Ministers, devoted his speech to the general problems of planning. The aim of planning, he said, was to speed up the tempo and this required direction of scientific effort along the most important lines; this in turn required insight into scientific tendencies and anticipation of the major revolutions in science and technology. Given this, it was necessary for the plan to determine the number of staff and amount of material which would be needed. Scientists and scientific research organisations should therefore take part in the planning of the work. Scientific establishments should be paid by results; not a few of them

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failed to reach the required standard and owed a heavy debt to the government. The planners, in other words, were not unnaturally demanding value for the money invested in scientific research. It was to take the Academy some time to re-organise to meet the new demands, and in fact the new organisation has been announced only within the last year.

IN the meantime the new State Research Co-ordination Committee has also had to establish itself. It was in fact formed from a previously existing organisation. The prototype was known as Gostekhnika (the State Committee of the Council of Ministers of the USSR on new technology) which was set up in July 1955. This was superseded in May 1957, when industry was reorganised on a regional basis, by the State Scientific and Technical Committee, which was given the tasks of 'studying the achievements of science and technology and production experience at home and abroad, publicising these achievements, publishing literature, supervising the development and introduction of new techniques, and co-ordinating the activities of scientific and technical committees of the Republican Councils of Ministers.' One of its duties was to act as engineer-consultant to the Council of Ministers on plans, and another was to give 'methodical guidance' to all organisations handling scientific and technical information, to make a technical examination of projects under consideration by Gosplan, and to provide an information service to the Regional Economic Councils. The State Scientific and Technical Committee was also responsible, jointly with the Academy of Sciences, for the gigantic All-Union Institute of Scientific and Technical Information (VINITI), which has become the largest scientific information centre in the world. It has a permanent staff of two thousand five hundred, including many highly qualified scientists, and over twenty-two thousand specialists are involved in the preparation of abstracts, of which over seven hundred thousand are published each year. Thus the State Scientific and Technical Committee had an interest in all branches of industry, including those which had their own state committees.

The new State Research Co-ordination Committee had tasks which were broadly similar to those of the former committee, but it had more power. Its importance was indicated by the fact that its chairman was to be a deputy chairman of the USSR Council of Ministers, whilst the chairmen of the other State Committees ranked as Ministers. The new committee was given executive powers whilst the old committee had been an advisory body. It was instructed to exercise control over all key scientific research, to initiate research on problems of major economic importance, to draft annual and long-term financial plans for scientific research, to approve suggestions for the creation of new scientific research institutes, and to co-ordinate international scientific and technical contacts of ministries, committees, and state research organisations.

In the three years following these upheavals, the State Research Co-ordination Committee and the All-Union Academy of Sciences have been settling down to their new tasks and agreeing about their spheres

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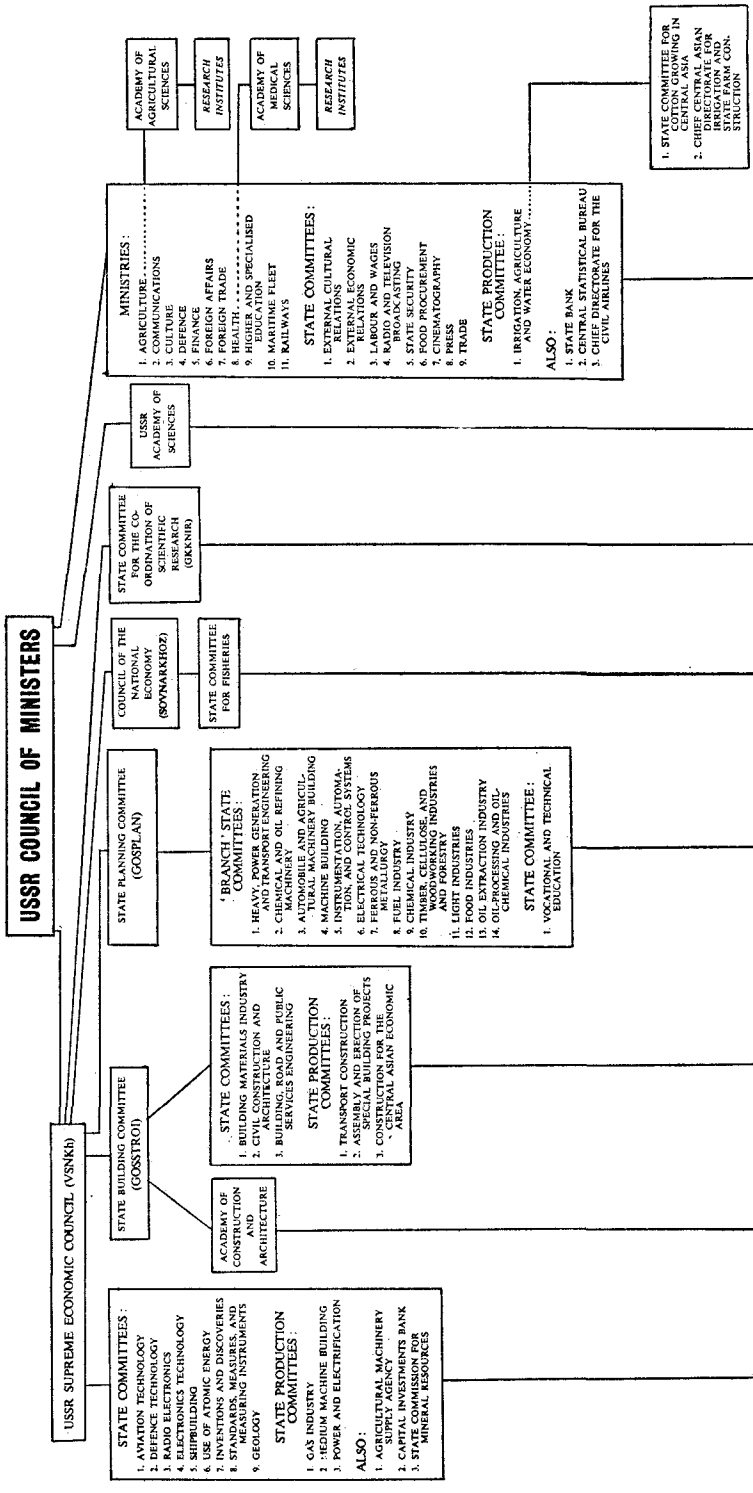

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of influence. A radical re-organisation of the Academy was announced in April 1963. It was stated that the Technical Sciences department had been disbanded. Many of the institutes within the department had already been transferred to industry or to Technical State Committees, and those remaining with the Academy were to be transferred to other departments of the Academy. So ended the argument about the Academy's technology division. As for the problem of reconciling the increasing need for specialisation with the need for cross-fertilisation between the different disciplines, the chosen solution is to divide the Academy into fifteen departments arranged in three groups, the physical-technical and mathematical sciences, the chemical-technological and biological sciences, and the social sciences.

The Academy seemed to have suffered a severe blow to its prestige in 1961 with the creation of the co-ordination committee, but there is every sign that, under the leadership of Academician Keldysh, it has recovered its authority and influence whilst operating in a narrower field. The announcement of April 1963 made it clear that the State Research Co-ordination Committee is to concentrate on the industrial or application side. The Academy has been made responsible for directing and co-ordinating scientific research in the natural and human sciences not only in its own institutes but also in the institutes of the Republic Academies and higher educational establishments.

In financial terms the academies all together are now responsible for only a relatively small part of the country's research and development effort. Many research institutes are responsible to the Regional Economic Councils, and in these institutes the emphasis is on development and application. Some other institutes come under the authority of the state committees and ministries. Changes were also made after the November 1962 plenum of the central committee—a regrouping of state committees, and the creation of a Supreme Economic Council and a Council of the National Economy.

There are of course Councils of Ministers in every republic together with republican Gosplans, State Committees, Ministries, and republican Academies of Sciences. Most of these bodies are responsible for research institutes. The tendency in economic planning is for the All-Union Gosplan to deal directly with the republican Gosplans rather than through the USSR and republican Councils of Ministers. Similarly, in scientific and technical fields the All-Union Academy deals directly with the republican Academies and the All-Union State Co-ordination Committee directly with republican Co-ordination Committees. The complexities of co-ordinating effort on this scale are enormous. It is small wonder that many Soviet scientists and economists look to electronic computers to provide the means for dealing with the problem.

SO far nothing has been said of research in the universities. These come under the authority of the Ministry of Higher and Specialised Secondary Education. The amount of research in the universities is

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relatively small, since the view has apparently been taken that universities exist to teach and research institutes exist to do research; consequently financial grants for university research seem to have been small compared with those to the Academy of Sciences. Some university teachers were taking on work in research institutes in order to combine teaching and research, but the practice met with official disapproval and was limited by decree in December 1959 and June 1960.

It is generally agreed that a split has occurred between education and research, and although the importance of healing this split is stressed regularly in articles and speeches, great practical difficulties are being encountered in bringing it about. Academician Lavrentiev, Chairman of the Siberian division of the Academy of Sciences (Novosibirsk), has advocated that a number of universities be handed over to the Academy of Sciences. Alexandrov, Rector of Leningrad University, has called for *the combination of research and teaching institutes all over the country* into a series of great scientific centres. Academician Keldysh suggested at one time that the solution might be to extend the practice of setting up problem laboratories in higher educational establishments, to work on important problems and receive appropriate financial grants; he thought measures should be taken to lighten the teaching load on active research workers.

At the All-Union Convention of Higher School Workers in July 1961 Elyutin, the Minister for Higher and Specialised Secondary Education, said that 300 problem and branch laboratories and 30 research institutes had been created within higher educational establishments; at the beginning of 1961 there were fifteen branch and scientific research laboratories within the higher education establishments of Kuibyshev alone. It was decided to set these up rather than to build new research institutes. But the indications are that it will be some time before the split between education and research can be healed.

THE ties between science and industry are one problem. The need for 'philosophical guidance' is another. What evidence of 'philosophical guidance' of Soviet scientists is there today? Many of them have been thoroughly grounded in Marxism-Leninism in school, in college, and afterwards. But the direct influence of the philosophy on their thinking on scientific matters is surprisingly difficult for Western observers to perceive (that is, so far as the exact sciences are concerned).

The indirect effect is evident, for the Marxist view leads to the concept of science as an organism which thrives best when planned for, co-ordinated, and controlled with clear-cut economic objectives in view. The Communist Party's view has been expressed clearly enough; the duty of Soviet scientists and technologists is to provide the material foundation for the building of communism, to base their views on the principles of Marxism-Leninism, and to assist in the teaching of these principles; and they are to be guided in their efforts by the philosophers of the party.

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To quote from official Soviet sources [2]: 'The times in which we live are saturated with great historical events. The Soviet people, armed with the great all-conquering theory of Marxism-Leninism and guided by the Communist Party, are selflessly accomplishing tremendous tasks. The Communist Party points out to Soviet philosophers the only correct road for their activities—the road closest to life and to the practice of communist construction—and it is the philsophers who will show the scientists the correct road for their activities'.

How do the philosophers show the scientists the road today? The proposal of D. Blokhintsev, director of the Joint Institute for Nuclear Research at Dubna, and the answer he received, show how it is done. Blokhintsev said [3] that the success of the Soviet Union in the great competition with the capitalist world would depend largely on the position of their scientific planning and that, although great things had been achieved by the concentration of human and material resources on the most important practical tasks, difficulties arose when it came to planning the development of theoretical work. Here a revolutionary idea could upset one's calculations and it was dangerous to rely solely on one scientific school of thought or one group of scientists. It was still more dangerous, he said, to give such a school a patent on the truth of its opinions. He wished to see the different scientific viewpoints published so that the individual reader could himself make an assessment of each scientific tendency and take from each what seemed important, useful, and valuable. The answer came twelve days later in an article by P. Fedoseyev, Academic Secretary of the Department of Economic, Philosophical, and Legal Sciences of the All-Union Academy of Sciences, and B. Kedrov.[4] In the course of an article which discussed the fragmentation of science into smaller and smaller compartments and the problems of communication which arose from this process, the writers pointed out that for fully understood reasons every specialist had a tendency to exaggerate the importance of his own speciality. To avoid this tendency, 'reciprocal friendly criticism and creative discussion' were necessary; 'while mercilessly revealing and rejecting the smallest deviations from materialism and carrying on a decisive struggle against hostile ideology, every Soviet scientist must consider his views in the light of those of other scientists [provided that their] opinions are not directed against philosophical materialism, but are derived from a different understanding of the problem, [though] approached from the same positions of dialectical materialism . . .' The party philosophers, in other words, intend that the scientist shall have freedom to think in any terms he chooses, so long as these do not stray away from the concept of dialectical materialism.

The view that Soviet achievements in science stem from their ideology

2 'The Level of New Problems of the Building of Communism', *Voprosy Filosofii*, 1959, pp. 3–9.
3 'To seek out, to argue, and to dare', *Izvestia*, 4 September 1961.
4 'The unity of nature and the inter-relationships of contemporary science', *Izvestia*, 16 September 1961.

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is frequently expressed. Following Titov's space flight, an article in *Pravda* (27 August 1961) set out to give the scientists and engineers who were responsible for development work their share of the credit. 'As technology becomes more complicated and specialisation more narrow, scientists have greater and greater difficulty in communicating with one another. "The fruitful meeting [process]", occurring haphazardly under capitalist conditions, in our country is planned on the basis of dialectical materialism. This immeasurably increases our strength . . . Foreign scientists are astonished by the perfection and reliability of Soviet technology. It is difficult to explain to them that the reasons are ideological just as much as technological.' Few Western observers would agree with this diagnosis! Soviet successes are usually attributed to the liberal endowment of science and technology at the expense of other sectors of the economy.

But scientists must preach as well as believe. One of the instruments of the Communist Party in assisting workers in factory and field to an understanding of the Marxist world-view is the Society for the Dissemination of Political and Scientific Knowledge. Academician N. N. Semenov, its President, summed up its aims in the following words: 'In their everyday work, these organisations are striving to establish a workers' scientific world outlook, [formed] on the basis of Marxism-Leninism and in indissoluble contact with the practice and creative genius of the masses of the people . . . They are unmasking bourgeois ideology and waging a struggle with the relics of capitalism in people's consciousness. They are propagating the internal and external policy of the Communist Party and the Soviet Government, the latest achievements of our science and technology and our advanced industrial experience' (*Pravda*, 27 October 1961).

Fedoseyev and Semenov seem to be saying, in effect, that science and philosophy are indissolubly united, but it is not the function of science to illuminate so much as to be illuminated by philosophy. Previous ideologies were rendered out of date by Marx and the march of scientific knowledge. From that stage forward, the truth having been revealed, science became a conservative force.

THE implications of these views in the present day context become clearer when the Communist Party programme is studied. The programme, adopted at the 22nd congress of the Party in 1961, outlined the tasks of the Party in building a communist society, and one section was devoted to the tasks in the field of science. In many ways, and especially in the physical sciences, the tasks are remarkably similar to those laid down, for example, by the Republican Party of the USA,* but in the biological and social sciences the Communist Party's line is quite different. The programme says that it is essential 'to develop more broadly and deeply the Michurin line in biology which is based on the

* See p. 46 in this issue.

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proposition that conditions of life are primary in the development of the organic world'. Lysenko's assertion that acquired characteristics can be inherited is not reiterated but this statement seems to come rather close to it.

It is in the section on the social sciences, understandably, that the Marxist view is most in evidence. 'There must be intensive development of research work in the social sciences', the programme says, 'which constitute the scientific basis for the guidance of the development of society. Most important in this field is the study and theoretical generalisation of the experience gained in communist construction; investigation of the key objective laws governing the economic, political, and cultural progress of socialism and its development into communism, and elaboration of the problems of communist education. . . . The investigation of world history and contemporary world development must disclose the law-governed process of mankind's advance towards communism, the change in the balance of forces in favour of socialism, the aggravation of the general crisis of capitalism, the break-up of the colonial system of imperialism and its consequences, and the upsurge of the national-liberation movement of peoples. . . . The social sciences must . . . uphold the purity of the principles of Marxism-Leninism.'

The dialectic is not so rigid as might perhaps be inferred from some of the statements which have been quoted. It can be interpreted in different ways and the interpretation is now very different from what it was in Stalin's time. Discussion of the basic problems to be solved in planning scientific research on a national scale appears in Soviet newspapers from time to time, stimulated no doubt by the intense reappraisal and reorganisation of scientific efforts which is going on there as elsewhere. An article by Academician Artsimovich (*Izvestia*, 24 January 1962) is especially interesting. He divides science into the two categories, fundamental and applied, but he further divides fundamental science into synthetic and analytical. The former is motivated, he says, by ultimate practical applications, but the latter 'deals with the natural laws which are at the basis of everything and where our conceptions of matter and even perhaps space and time are liable to need revision at any moment'. Science, in other words, is accorded its own logic of development. If the dialectic forbade that in the past it appears not to do so today—or does it?

Artsimovich and Kapitsa [5] mention problems many of which are common to scientific research inside and outside the Soviet Union. The 'industrialisation' of the exact sciences leads to experiments of such size and complexity that 'collectives' of workers are needed. Specialists in various fields must work together. There are communication problems and incidentally the difficulty of deciding who is to receive the credit for this or that discovery. The impact of cybernetics, one aspect of which is the introduction of computers, is changing the range of problems which

[5] 'Theory, Experiment, and Practice', *Ekonomicheskaya Gazeta*, 26 March 1962.

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can now be tackled and the way in which they are tackled. These need no longer be reduced to the simple form demanded by classical methods. There is the increased difficulty in drawing the line between science and technology, and there is a change-over in certain fields whereby science now tends to precede rather than to follow technology. There are, Kapitsa says, too many theoreticians and too few experimenters. And the need is stressed for men with a broad outlook; top-rate specialists are not enough. These are world-wide problems, excepting perhaps the excess of theoreticians.

Some writers are forthright about the lessons which can be learned from the West. Academician Tamm, writing about the need for research work in the higher educational establishments (*Izvestia*, 2 January 1962), remarked that the holding of two or more appointments, though usually bad, was 'unconditionally desirable' in the case of scientific research and teaching. 'It is not without interest', he wrote, 'that in the United States a great deal of research work is concentrated in the higher educational establishments'.

To sum up, the trend in the organisation of Soviet research and development is towards agencies responsible for co-ordination of effort on a nation-wide scale. The chief of these are the All-Union Academy of Sciences (broadly speaking this is responsible for pure scientific research), and the State Research Co-ordination Committee (responsible for applied work). The whole effort is also linked on a subject basis by means of the Scientific Councils which aim to govern the work along each major 'basic direction'. Co-ordination on this scale is a gigantic task. 'Philosophical guidance' is in evidence but has little obvious direct effect on the development of the exact sciences.

There are many points of similarity, but even today important points of difference between the Soviet and Western attitudes to scientific research and its planning. If the differences are smaller than they were in the past, it does justice neither to the Marxist nor to other viewpoints to underestimate them.

* * * *

It is a commonplace to say that we shall learn to understand one another only by talking to one another, but it is vital to remember it. Fortunately in recent years there has been a great increase in the number of opportunities for contact. This is especially noticeable in the fields covered by the exact sciences and technology, where the similarity between Soviet and Western developments makes a good starting point.

So far as Anglo-Soviet contacts are concerned, the significant change came in 1959. A few exchanges had already taken place by that date; for example, in the scientific and technical fields, the Royal Society, the Atomic Energy Authority, the British Iron and Steel Research Association, and a number of British firms had exchanged delegations with corresponding organisations in the Soviet Union. The exchanges were, however, much widened in scope after the Prime Minister's visit to

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Moscow in 1959, when a cultural agreement was negotiated between Britain and the USSR which put the exchanges on the official basis which is more acceptable to the Soviet way of thinking.

There are other signs of improving contact. A separate agreement was negotiated in 1961, between the United Kingdom Atomic Energy Authority and the Soviet State Committee for the Utilisation of Atomic Energy. British scientists and technologists visit the Soviet Union by invitation of Soviet organisations or to attend international meetings, and Soviet scientists and technologists visit Britain on the same basis. Useful exchanges have developed in the arts, in sport and so on. There are more tourists. And what is true of Britain is true of many other countries.

The scale of the traffic is still very small compared with that, for example, between Britain and the United States; but when one remembers conditions of even a few years ago the improvement is encouraging.

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REORGANISATION: 1963

James M. Swanson

AT a general meeting of the USSR Academy of Sciences in May 1963, its President, M. V. Keldysh, presented a report 'On Measures to Improve the Activity of the USSR Academy of Sciences and the Union Republic Academies of Sciences' which called for a major reorganisation of Soviet science—the second reorganisation in two years.

To view this solely as an attempt to bring science into line with recent changes in the structure of the economy would be misleading. While it is true that the new science reform was worked out at the same session (in November 1962) of the Central Committee which discussed guidelines for management of the national economy, the problems in the organisation of science were somewhat different. For one thing, administrative machinery for a centralised direction of science was already in operation. The State Committee for the Coordination of Scientific Research, created in 1961, had as its major purpose the centralised control of the nation's research effort, and was also responsible for 'ensuring the necessary coordination of the work of the country's research institutions, improving planning of scientific research, and the introduction of scientific and technical achievements into the national economy'. This important assignment is now at least shared by, if not completely transferred to, the Academy of Sciences.

It is difficult to resist the conclusion that the change was made necessary because the State Committee was ineffective. It was, for example, specifically criticised for failing to effect a 'proper utilisation of scientific resources'. Until more information is available regarding the delineation of responsibility, any final conclusions about the respective roles of the Academy and the Committee would be premature. The new reorganisation unquestionably enhances the position of the Academy of Sciences, but the continued existence of the State Committee raises some fundamental questions about the 'unified' direction of science which Academician Keldysh said would be facilitated.[1]

One of the first indications of an impending change in the scientific structure came in mid-March 1963. The State Committee was released from direct subordination to the USSR Council of Ministers and transferred to the newly created Supreme Council of the National Economy. Two months later, M. V. Keldysh presented his report to the assembled academicians. It called for the Academy to assume control over the following functions:

1. Determination of the basic directions of scientific research
2. Coordination of work in these areas

[1] *Vestnik Akademii Nauk SSSR*, No. 6, June 1963, p. 12.

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3. Drawing up draft plans for the most important research work on the basis of proposals presented by the Union Republics, Ministries, and other departments
4. Orientation of financing, material-technical supply, and capital construction in the scientific institutions connected with the Academy of Sciences and the Union Republic Academies
5. Development of scientific research carried out by the Union Republics, higher schools, and other institutions including the creation of new research institutes
6. Improvement of the utilisation of scientific results in the economy and relating scientific activities more closely to production.[2]

Experience over the two years after the 1961 reorganisation had revealed that, like the economy as a whole, the emphasis on regional autonomy in science tended to divert attention from problems of national importance, despite the existence of a national coordinating body. There was widespread duplication as Union Republic Academies of Sciences and other organisations of regional scope attempted to become self-sufficient units in scientific research. New establishments had been created which paralleled institutes in other regions.

THE recent reorganisation of the Academy was designed to eliminate the problem of controlling science on a day-to-day basis. Instead of relying entirely on scientific councils, the divisions of the Academy will be responsible for the continuous coordination, planning, and control of work in their own special field. According to Keldysh, these new duties necessitated a revision of the eight divisions in the Academy. There are now fifteen divisions. Greater specialisation, and thus closer correlation to actual developments in modern science, is facilitated. The new divisions are[3]:

1. Mathematics (uniting the direction of all mathematical sciences, in particular the development of computer mathematics, the theoretical foundations of cybernetics, the logical foundations of computer theory)
2. General and applied physics (uniting research on the physics of solids, liquids, and gases, optics, acoustics, radio physics and electronics, astronomy and astro-physics)
3. Nuclear physics (including research on the physics of atomic nuclei, elementary particles, and cosmic rays)
4. Physical-technical problems of energy (methods of transforming and producing power)
5. Earth sciences (including the structure of the earth's core, methods of producing minerals, oceanic research, physics of the atmosphere, and physical geography)
6. Mechanics and control processes (research on mechanics, theory and technology of control processes)

[2] Ibid. p. 16.
[3] Ibid. p. 18.

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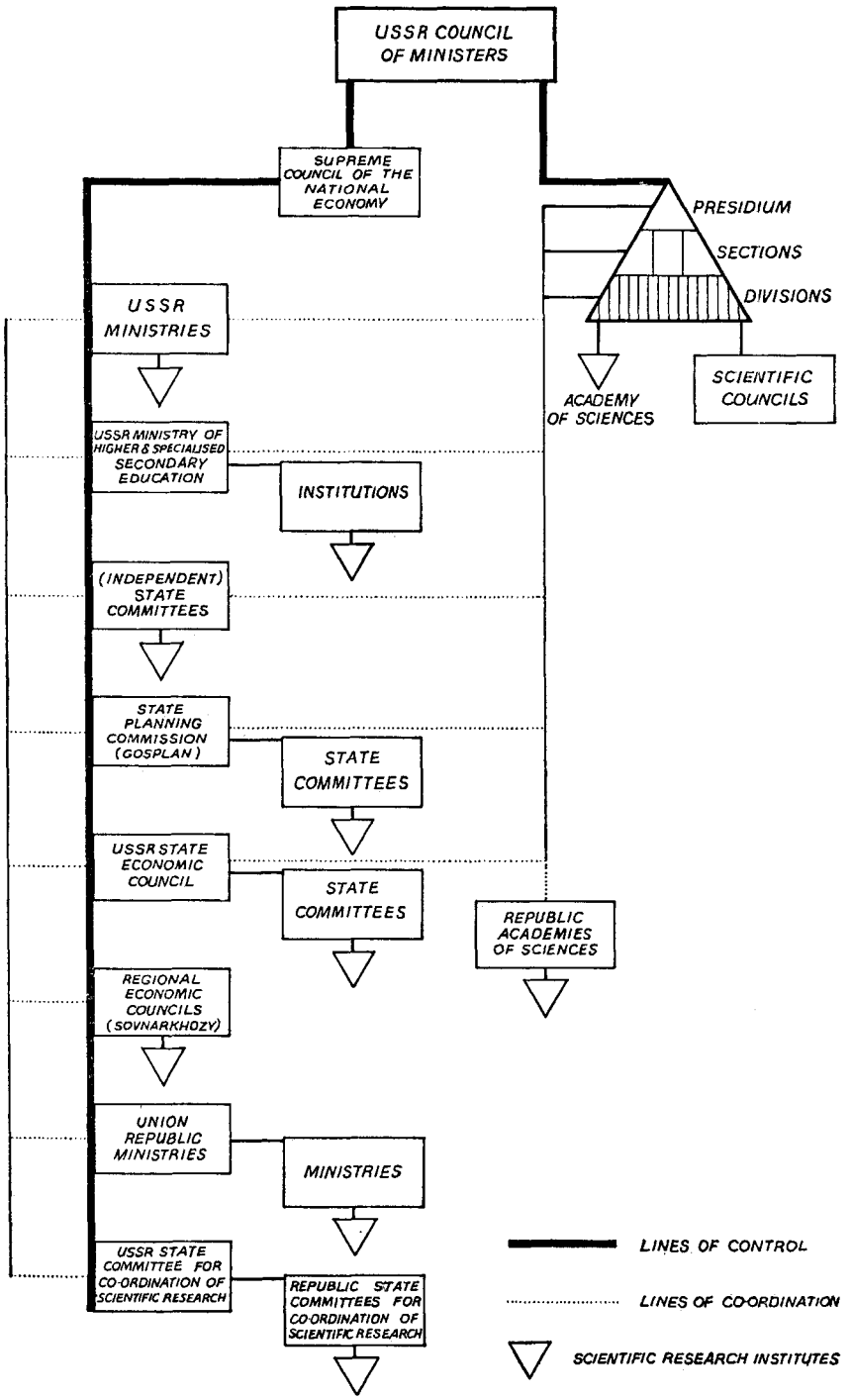

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7. General and technical chemistry (including organic and inorganic, the chemistry of polymers, monomers, electro-chemistry, radio chemistry, analytical chemistry, and the chemistry of pure and superpure substances)
8. Physical chemistry and technology of inorganic materials (including research on metals and new metallurgical processes, new inorganic materials, materials for radio and electronics, refractories, glass, etc.)
9. Biochemistry and the chemistry of physiologically active compounds (physical-chemical foundations of the organisation of living matter, physiologically active substances, agricultural chemistry, physiology of plants and microbiology)
10. Physiology (of man and animals)
11. Zoology, botany, and evolution
12. History
13. Philosophy and law
14. Economics
15. Languages and literatures

In practice the divisions will still rely on scientific councils, but only in connection with problems of a complex nature requiring the advice of scientists in a number of different specialities. The Presidium of the Academy will have only two permanent scientific councils of a general nature—one on cybernetics, and the other on the philosophical problems of natural science. It will determine the direction of research, present plans, and discuss general problems concerning the coordination of research. A special agency will supervise the work of the Republic Academies of Sciences and their research institutes.

The divisions will be controlled by three sections, each headed by a vice-president of the Academy. These sections, the Physical-Technological and Mathematical section, the Chemical-Technological section, and the Social Science section, will be subordinated to the Presidium. They will also act as coordinators of research for their respective divisions and will even control institutes of their own. Most of the Academy's research institutes will be controlled by the divisions.

THE 1963 reorganisation was not a complete surprise to Western observers. Since 1956 the Soviet scientific establishment has been in a constant state of flux. Several trends, however, can be discerned in this recent move. One is the growing emphasis on basic research [4] and the institutional separation of scientific and technological functions. The process of transferring research institutes with industrial profiles from the Academies to State Committees for industry and defence or to Ministries, a programme initiated in 1961, is being continued. A reciprocal transfer to the USSR Academy of Sciences of institutes with theoretical functions is being urged.

[4] The term 'pure science' is rejected in the Soviet Union. It has an unsavoury 'bourgeois' flavour to ideologically-oriented Soviet scientists. The term 'fundamental', 'basic' or 'theoretical' research is preferred.

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Another trend is the growing role of the universities and other higher and specialised secondary educational institutions in scientific research. In this respect, the Soviet Union is moving closer to the West. Since the 1958 educational reforms, particular emphasis on the extension of this activity can be noted. Mr. Khrushchev has come out strongly for this expansion. Although the proposal to transfer research institutes to the universities has been relatively unsuccessful, special attention was paid to the plight of university research in the recent reform.

In contrast to the 1961 reorganisation, little official comment about the 1963 reform has appeared in the press. This much can be inferred however. More changes are likely to occur in the near future as practice dictates necessary revisions. Unlike Western Europe and the United States, both of which are relying more and more on guiding research through such external pressures as establishing priorities for governmental support and even drawing up plans for future scientific development, the Soviet Union has a long history of intervention in shaping the internal structure of scientific institutions. The essentially bureaucratic belief that a reshuffling of organisational structures and administrative responsibilities produces effectiveness in operation is characteristic of Soviet institutional philosophy. But the magical formula has yet to be discovered.

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PROSPECTS OF SCIENCE

A Soviet Vision

N. N. Semenov

TO liberate mankind from heavy physical labour as well as from labour which is repetitious, monotonous, demanding no thought: to provide everybody with food, clothing, and housing, in other words to make all people truly free and to bring within their reach, according to their abilities, the joys of creativeness, the delight in cultural and spiritual treasures—is this not the basic humanist idea, which is dear to all honest people?

Contemporary science and technology are continually opening up new possibilities to satisfy the material needs of people, up to the level of their reasonable requirements. If the social system in which power belongs to the true creators of wealth—the workers—prevailed in the whole world, mankind would already have been able to live in prosperity and to make use of all the benefits of civilisation.

What are the basic scientific, technical, and economic problems whose solution is most important for the welfare of the people?

The power supply, in particular the volume of electricity, is of basic importance for the level of industry, agriculture, and the life of the people. At the moment, the average amount per head of power produced in the world is about 0·1 of a kilowatt; which is very little. With this electric power supply, heavy physical labour is inevitable, particularly in economically underdeveloped countries.

It is clear, however, that natural resources permit this quantity to be increased many times. The Soviet Union can serve as an example of this, having increased its electric power production more than 160 times during its existence. If the production of electric power in all countries grew at the same rate as in the USSR, by the year 2000 it would be possible to increase its output more than 50-fold. The production of electric power can be increased by a rise in the efficiency of electric power stations and by the opening up of new sources of energy.

Many ways of raising the efficiency of power stations are being projected. Particularly promising is a fuel cell working on oil and coal as raw materials, which would raise the efficiency of conversion from the chemical energy of the fuel to electrical energy to nearly a hundred per cent. Besides, the fuel cell could work automatically and would thus be particularly useful for the electrification of transport or for agricultural and building machinery.

The reserves of mineral fuel are not yet fully determined. However, the present sources of power, i.e. the reserves of coal and oil, deposits of uranium and thorium, are not boundless; therefore the problem of new energy sources naturally arises.

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Unique possibilities would be open to mankind if it were possible to achieve controlled thermo-nuclear reaction. This seemed impossible, as such reaction emits enormous amounts of heat, while the temperature within the reaction zone reaches hundreds of million degrees. It is obvious that the walls of a ' thermo-nuclear furnace ' would immediately evaporate. Physicists (as far as I know, Soviet physicists were the first to do so) have proposed the principle of magnetic isolation which diminishes the transfer of heat to the containing walls and makes this process possible. They succeeded by means of a powerful electrical impulse in heating the material for a moment to high temperatures which, while not sufficient for thermo-nuclear reaction, enabled them to check the basic principles of magnetic isolation. However, at present the question of a continuous, regulated thermo-nuclear reaction is still far from a solution. New ideas are needed here. When this important problem will be solved, whether tomorrow or after many years, it is as yet impossible to forecast precisely. I think, however, that it will happen before the end of the twentieth century.

What will be the results of mastering thermo-nuclear reaction?

In thermo-nuclear processes, energy is emitted by means of conversion of light atoms, mainly the atoms of deuterium (heavy isotope of hydrogen), into the more stable atoms of helium. The conversion of one gramme of deuterium gives 10 million times more energy than the burning of one gramme of coal. Deuterium is present in ordinary water in quantities of 1/63000 to 1/45000 by weight, and could be extracted by processes which have been already worked out. Thus, one litre of ordinary water potentially contains as much energy as the heat produced by burning 160 kg. of coal, while 260 cubic metres of water contains energy resources equivalent to the total world annual coal production.

Up-to-date technology often demands high temperatures; the current methods of producing these temperatures are expensive and insufficiently effective. The circumstances will be very different when controlled thermo-nuclear reaction is achieved. In addition to electric power, very high temperatures will be obtained as a by-product. In these temperatures, materials will decompose into atoms, which will be present in their gaseous state. A rapid cooling of such chemical systems can yield various combinations. In particular, oxides of nitrogen for fertilisers, obtained from air by this means, will probably be the cheapest way of fixing atmospheric nitrogen.

It is also useful to mention here that the electric power obtained in thermo-nuclear reactions will be very cheap and easily available. This will lead to a fundamental change in the chemical and metallurgical industries. Non-organic and organic products will be obtained by electro-chemical processes, by electrical discharge, by radiation processes, as well as by electric heating.

IS there a limit to the increase in the total electric power station capacity, should thermo-nuclear energy become available?

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I believe that such a limit exists. It is determined by the heating of the earth's surface and atmosphere as a result of the heat discharged during thermo-nuclear reactions. When the heat discharged from thermo-nuclear boilers reaches 10 per cent of the solar energy at the earth's surface, the earth's mean temperature will probably increase by 7 degrees. This will probably lead to a rapid thaw of the Arctic and Antarctic ice and could result in floods all over the world and other unpleasant consequences. Therefore the output of thermo-nuclear power will probably not exceed 5 per cent of solar energy. Even this, however, means that it would be possible to obtain 12,500 times as much electrical power as at present. With a population 10 times the present, power per head will be 125 kilowatts—1250 times the present average.

It is, however, necessary to mention here that at the moment electric power accounts for only 5 per cent of the total energy used by man. Therefore, given the maximum use of energy produced by thermo-nuclear reaction, the general consumption of energy per head of population will increase not 1250-fold, but 60-fold. But this figure is still enormous, particularly if the greater value of electric energy is taken into consideration in comparison with thermal energy. Thus, the energy resources will be sufficient for the complete welfare of humanity, even if population increases by scores of times.

Equally great prospects would open for humanity should we learn to transform solar energy into electrical energy with an efficiency rather greater than that achieved by plants. Every second, the sun sends to the earth 4×10^{13} (i.e. 40 trillions) of kilo-calories. The greater part of this energy, it is true, is partly dispersed and partly absorbed by the atmosphere. About 40–50 per cent reaches the earth's surface. If all this energy was transformed into electric energy with an efficiency of, say, 20 per cent, we would get more electric energy than from the maximum use of thermo-nuclear power. True, it is not possible in practice, as to do this it would be necessary to cover the whole earth's surface, land and water, with photo-electric cells and other devices containing light-sensitive liquid. But even one tenth of solar energy would be sufficient to meet in full the requirements of a population scores of times larger than at present. This is the second great potential source of energy.

It is obvious that, in addition to big technical difficulties, the solution of the problem will require considerable scientific work. It would be necessary to invent catalysts with a sufficiently high efficiency rate to transform solar energy into chemical energy. I believe that this task can be solved by organised scientific work.

There is a third, enormous potential source of energy—the underground heat of the magma. This involves no scientific problems of principle, but technical difficulties for the utilisation of this source of energy are probably very great.

Thus we see that in addition to coal, oil, uranium, and thorium, there exist much greater, practically inexhaustible, sources of energy. If we

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master these, we could fully satisfy the electrical power needs of the growing population of the globe.

Many different materials are needed to provide people with housing, household goods, and clothing; for the construction of farms and hothouses; for the provision of water supplies, for canalisation and irrigation; for the construction and equipment of factories, electric power stations, transport, etc. The use of thermo-nuclear or solar energy will create a basis for obtaining these materials in unlimited quantities. The widespread use of electrolysis and electrical heating will alter the nature of contemporary metallurgy. Aluminium will be more important than iron. It will probably be possible to make considerable practical use of boron and other common materials. Very durable, heat and corrosion resisting alloys will be widely applied. The variety of non-organic construction materials will be considerably extended. The production of cement and concrete will be increased and basically changed; a quarry opened anywhere will yield valuable construction material.

HOWEVER, the most characteristic materials of the future will be new products of organic synthesis—polymers, i.e. plastics, synthetic fibres, rubber, fur, and so on. It is already obvious that within this century the materials created by chemical science during the last few decades will be dominant in industry, construction, and everyday life. Synthetic polymers will crowd out natural polymer materials and will make it unnecessary to grow such plants as cotton and flax. In addition they will, to a great extent, take the place of metals as they are just as durable, more resistant to corrosion, and more easily worked, and in future they might also be made more resistant to heat. Techniques will be truly revolutionised should science discover methods of obtaining non-organic polymers with the desired mechanical attributes, because the raw materials for their production are inexhaustible.

The volume of output of organic polymer products is determined by the availability of sources of the necessary raw materials, oil, natural gas and coal, wood pulp, etc. At the present moment, oil is mainly used for the production of fuel, particularly for surface, air, and water transport, and to a lesser extent, for thermal power stations and heating. If, as a result of the use of thermo-nuclear and solar energy, the resources of electric power were to become sufficiently great, all these various ways of oil utilisation could be brought down to a minimum. In this case it could be used basically as raw material for the production of synthetic polymer products.

The problem of a rapid improvement in the resistance to corrosion of materials and the consequent increase in their durability is already of considerable importance. The problem of re-use of materials is equally important. Materials used in manufactured articles are a rich source from which the original material could again be produced at little cost. Finally, it might be possible to increase the durability of materials scores of times and so rapidly diminish their rate of consumption. The fact

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is, that the actual durability of present-day materials is incomparably less than the theoretical one, if one judges by the forces known to operate between atoms. One of the important tasks facing science is to find out exactly the reasons for this discrepancy and the methods for eliminating it.

Enormous economies in man's labour appear possible as a result of the development of telemechanics, electronics, and the automation of production processes. Automatic equipment promises to revolutionise production in the near future. Its data suppliers are sensitive elements which are capable of determining temperature, pressure, hardness, the composition of materials, and dozens and hundreds of other qualities, and to inform the electric controlling system of any alteration in them.

Until recently the central link in these systems was the electronic radio-valve. Within the last few years, we have witnessed a revolution in the field of electronic techniques, which has come about through the introduction of semi-conductors: small, inorganic crystals or films which take the place of the electronic valve. Here the movement of charged particles takes place not in a vacuum, but within a crystal grid of a solid body. Semi-conductors make it possible to reduce considerably the size of the apparatus, and in many cases to make it more reliable. It is within the bounds of possibility that organic polymer materials will open up some new possibilities for electronic techniques. Practical successes in this field are apparently so far on a modest scale, but many scientists in various countries are working on this problem.

A further revolution in the field of automation and communications is promised by a field of knowledge which has come to the fore recently, that of quantum radio-physics and radio-electronics. It is based on the existence of a radiation of a special type, so called inductive radiation. The possibility of its existence was predicted by Einstein as far back as 1917. Inductive radiation consists in the emission of a quantum by an excited particle as a result of being hit by a similar quantum. Moreover, quanta can be emitted by material in a chain reaction.

For many decades, research workers ignored the possibilities which the realisation of this process would open up. Soviet scientists have for a long time stood on the threshold of the discovery, having pointed out in 1940–41 the possibility of light intensification by induced radiation. However, the real revolution in this field came only at the beginning of the fifties, when in the USSR, USA, and Canada simultaneously, a new principle of generation and intensification of radiation was advanced, based on induced radiation. Roughly speaking, if a system is created where there are more excited particles than particles into which they are converted when emitting a quantum, and when there is a possibility of making the quantum ' run ' a long time over the material, then we would get the desired chain process of radiation.

The prospects of quantum radio-physics are truly enormous. It is sufficient to point out its use in the construction of the atomic clock, which deviates no more than seconds in the course of hundreds and

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International Comparisons

TO BUILD A MOUSE-TRAP or a national science policy you must have a model of a mouse-trap or of a national science policy. Models of science policy were produced long before any government in the world made the development and the use of science a major national task. The earliest such model I have been able to find is Thomas Sprat's *The History of Royal Society* written in 1667, soon after the discovery of the scientific method. Applying Bacon's philosophy of interaction of science and society, Sprat presented 'A model of their (the Royal Society's) whole design', and showed how by 'natural philosophy' the major national objectives (he called them 'universal interests') of the United Kingdom of his time could be achieved—including the solution of the problem of 'want of employment for younger Brothers, and many other conditions of men'.

According to Sprat, however, certain social conditions must exist in order to translate 'the whole design' in a few heads into action by many. These conditions were lacking early in the 17th century and Sprat says that 'even my Lord Bacon with all his authority in the State could never raise any College of Salomon but in a Romance'. . . .

The international comparisons of present-day science presented in this article aim to stress more what is similar than what is dissimilar in the interactions of science and society in different parts of the globe, following Chekhov's saying, 'There is no such thing as a national science, as there is no such thing as a national multiplication table'. In making these comparisons I shall follow rather boldly, in view of the embryonic state of the art of measuring science, the dictum of Sprat's contemporary, Sir William Petty, that when speaking of policy, 'one has to express oneself in terms of number, weight, and measure'.

Science policy in a country depends in the first place on the 'affection' for it, on the science ideology of its leading institutions. The table shows a number of common elements in the science ideologies of two political organisations from two ends of the world political spectrum: the Communist Party of the Soviet Union and the Republican Party of the USA. Policy statements on science in a number of other countries, including, for example, Harold Wilson's speech at the British Labour Party Conference last year, would fit the table equally well. The table speaks for itself; one need add only that most science policy documents, including the Republican Party one (though not to the same degree or in the same way), accept the most important social invention of our century, social planning, as applied to planning science. Today, in contrast with a generation ago, governments, bankers, industrialists and spokesmen for the scientific community want to plan, as a matter of course, scientific manpower and research expenditures. They even want to determine what is called in the East 'the principal directions of growth of science' and in the West 'the growing points of science' in order to plan national research programmes.

Neglecting the glaring differences, how do these and other similarities of views on science of Soviet Communist and US Republicans arise? One first notes that, through more intensive contact and communication, all countries throughout the world, and hence the majority of their

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political parties, are slowly adopting and pursuing increasingly similar and more compatible national objectives. . . . Science is becoming a major tool for achieving the national objectives. . . . A national science ideology, as distinguished from the general ideology, is based to a considerable degree on a country's appraisal of national and international experience with science. High-level decision-makers have observed that the general problems of developing, managing and using science tend to be strikingly similar in whatever country they turn up. . . .

Stevan Dedijer

Some Common Traits in Science Policy Ideologies

	Republican Party USA	Communist Party USSR
document	'Decisions for a Better America', published by the Republican National Committee, October 1959	'Programme of the Communist Party of the USSR', *Pravda*, 30 July 1961
how science acts on society	'revolutionises methods of production, changes social relationships . . .'	'key growth factor of social productive forces'
current state of interaction	'scientific revolution'	'scientific-technological revolution'
defined as	'at least 16 revolutions', including automation, power and atomic energy, chemistry, biology, space research . . . and 'planning by business, government, banking . . .'	'automation, nuclear energy, chemistry, biology, space research, etc.'
importance of science	'our nation needs a strong science and technology'	'the development of science . . . will continue to be a special task for the party'
what to do	'consciously and purposefully to expand the scientific revolution'	'carry out the scientific revolution and utilise its results'
how; some specific tasks	'basic science must . . . be fostered' 'provision of scientists with . . . economic resources' 'develop scientific talent of highest quality'	'the development of theoretical (basic) research in natural and social sciences' 'improve the material base of science' 'attract into science the most creative talent'
scientists' role in science policy	'President's Scientific Advisory Committee to represent views of scientific community'	'the role of the scientific community in deciding on research must increase'

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thousands of years, to note the thousand-fold increase in the number of possible communication channels, the reception of radio waves from the farthest corners of the universe.

Particularly exciting to the imagination are the light beams which can be obtained with the help of optical quantum generators. These beams can be concentrated on such a small area that a light intensity of many million atmospheres is created. In principle, with the help of such beams, one could even now establish communication with objects which are several light-years distant from us.

PARTICULARLY important prospects are opened for mankind by the rapid development of mathematical logic and by the use of electronic calculating machines. As machines which do mechanical work free men from heavy physical labour, so the electronic calculating machines are destined to free him from those kinds of brain work which do not demand creative thought and are, in a great measure, automatic, such as, for instance, the handling of automatic production lines, of the movement of transport, and many types of office work.

In the near future calculating machines will be able to give information on an enormous number of questions, Moreover, they will give information which is systematised and partly analysed. It is the continuous increase in the volume of scientific material as a result of the rapid development of science which makes wide creative scientific generalisation so difficult, complicates the comprehensive consideration of phenomena, and turns scientists into narrow specialists. Electronic machines are destined to remove this contradiction, and to allow man to concentrate his mental forces to a much greater extent than at present on truly creative processes.

The most important problem in the design of new electronic calculating machines is to increase the volume of information with which they can deal, while keeping them to a reasonable size. Semi-conductors have already played a considerable part in the solution of this problem. We can now expect considerable success from the use in this field of quantum radio-electronics, which are capable of processing and transmitting enormous streams of information.

In a communist society, the steady expansion in the automation of production processes will sharply alter the character of man's working life. The industrial working day could be shortened to, say, 3–4 hours, which would leave ample leisure for various occupations, in the first place for creative activity, but also for rest and sport.

One of the greatest problems of welfare is the provision of adequate nourishment. A considerable proportion of humanity is at present undernourished, and there are places where hunger is a frequent visitor. At the same time, if cultivation and the fertilising and irrigation methods of the arable land now in use were improved up to the highest level now

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in operation, it would be possible to secure ample high-quality nourishment not only for the present world population, but probably for a much larger one.

Given good agricultural techniques, mechanisation, and sufficient moisture, harvests of about 15 tons of dry matter per hectare are now obtained. Forty per cent of these, i.e. 6 tons, can be used by man for food directly. If the crops are sown for animal fodder, then all 15 tons can be used. However, only a small proportion of them, about 10 per cent, can be obtained from farm animals in the form of meat, milk, butter, fat, and eggs (calculated in dry weight).

The normal daily ration consists of about 1 kg. of dry food weight, of which plant food would account for about 75 per cent and animal food for 25 per cent. For the satisfactory nourishment of 3 milliard people, taking harvest yields as given above, it would require only 130 million hectares under crops used by man and 180 million hectares under fodder crops. This accounts altogether for 2·2 per cent of the land mass (not counting the Antarctic). This is one-quarter or less than the agricultural land in use at present. However, the average consumption is much less than the norm indicated, and it follows that the average yield is at present many times lower than the maximum possible. The land now in use could feed a population at least 5 times as great as the present, and there seems no reason why up to 30 per cent of the land mass could not be brought under cultivation.

In this connection, it is worth considering the question of maximum possible yields. The efficiency of photosynthesis amounts to about 10 per cent of the total solar energy. Since we know the average amount of energy which reaches each hectare during the vegetation period, the maximum possible yield per hectare can be calculated. It comes to about 5–6 times more than the 15 tons of dry matter mentioned. Thus, if agriculture is properly organised, ample nourishment can be provided for a population scores of times larger than the present.

WHAT are the main, decisive, fundamental problems of scientific principle which confront us at present? I see two such problems.

The first is in the field of physics: to establish a theory of elementary particles and a field theory. This touches probably the most important mystery of nature, the creation of the universe. I think that experiments in space will play a very large part in the study and in the solution of this problem.

The second main task, falling into the fields of chemistry and biology, is to comprehend the basis of the molecular physical-chemical processes which take place in living organisms. In the last few years many highly trained physicists and chemists have entered this field of biochemistry and biology, and considerable successes have been achieved, but these should be considered so far as clearing the way into this great and important field.

We have learned quite a lot about the molecular structure of the

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most important bio-polymer substances which make up the basis of an organism, such as protein and nucleic acids. We have learned something of the function and structure of enzymes and chloroplasts. Recently we have made progress in understanding the nature of heredity, the mechanism of reproduction and protein synthesis in an organism. Recent work in this field has led to the deciphering of the code which governs the protein molecular structure. We know something about the operation of the brain and nerves.

However, if we consider it seriously, we have only begun to establish the structure and stages in the process, while we do not yet understand the most important part, their chemical mechanism. This is the most important task.

We know, for instance, that some chemical substances exert a particularly strong influence on the mutation of organisms. Soviet scientists initiated this work. After seeds have been treated with these substances, the plants which grow from them possess many new qualities and are sharply differentiated, even in their external appearance, both from the mother plant and from each other. At the same time, amongst a multitude of changes some useful ones can always be found. In contrast to the action of X-rays, practically no destruction of organisms takes place. But we cannot even imagine what chemical mechanism is involved in this effect. If, however, it were possible to find this out, such a method would become basic for selection, and would open up much wider fields than the usual methods.

Knowledge of the chemical mechanisms of various biological processes would make possible the selection of powerful substances having a specific effect, for agriculture and also for medicine. It seems certain that this is the only promising line for the cure of cancer and cardiac-vascular complaints, and for assuring a healthy old age and longevity.

But this field of research has another side as well. If the mechanism of various processes in living organisms can be discovered, the new physico-chemical principles so established can then be used for the creation of entirely new types of chemical materials, technological processes, and machines. It would, of course, be quite unrealistic to try to copy these processes, but they can be adapted. Did not the study of the mechanics of bird flight lead to the creation of the aeroplane wing and to the emergence of aviation?

The enzymes of living organisms possess wonderful qualities which differentiate them from the best catalysts used in chemistry, in the first place their astonishing activity and their specific character. They ensure the reaction of even the most inert substances in normal temperatures and under normal pressure. Thus, with the help of enzymes, some bacteria easily assimilate atmospheric nitrogen, while with the use of artificial catalysts, ammonia is formed from nitrogen and hydrogen only in high temperatures and under high pressure. In the process of evolution, living organisms by necessity learned to be very economical;

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they use insignificant amounts of catalysts for dealing with a large amount of 'raw materials'.

Finally, the most important feature of the catalytic system of living organisms is the fact that with their aid most complicated polymeric molecules are formed, of a strictly predetermined composition and structure.

It may be possible, having studied the operation of enzymes, to make much simpler synthetic catalysts, which would have a somewhat less specific character but would be much more powerful than enzymes. This would lead to a revolution in the chemical industry.

Study of the chloroplast action mechanism might make it possible to manufacture catalysts for the photochemical use of solar energy and for its transformation into electric energy. Understanding of the mechanism of muscular movement would permit the creation of entirely new machines working on the principle of muscular contraction. Research into the mechanism of nerve stimulation and the operation of the brain cells would make it possible to construct miniature calculating machines. Knowledge of the mechanism of bacterial action would help to create effective catalysts for the fixing of atmospheric nitrogen. For the time being, all this is fantasy, but how many fantasies have become reality with the development of science!

The development of catalytic chemistry has already confirmed the possibility of creating systems close to enzymes. Thus, the operation of the recently discovered complex catalysts of polymerisation is to some extent reminiscent of the operation of enzymes. With their help, polymerisation of ethylene, propylene, and other substances takes place in atmospheric pressure and room temperature, which was impossible before.

Some of these catalysts are reminiscent of microelements in the effectiveness of their action. Thus, in some systems which contain vanadium, an insignificant quantity of this element permits a large quantity of polymer (up to a ton for a gramme of vanadium) to be obtained. We must also mention that in complex catalysts, compounds of the same elements as in bio-catalysis are used.

Perhaps the most important feature of catalysts of polymerisation is the fact that they are capable of making polymers with a particular spatial arrangement of monomer bonds (so called stereospecific polymers), which possess particularly valuable properties. Catalysts act as matrices in which the reacting molecules of monomers are laid down in a definite manner. Although in an incomplete form, this attribute of catalysts is reminiscent of the attribute of enzymes in the synthesis of ordered molecules of protein.

The possibilities which are open to science and technology are truly extraordinary, and I have mentioned here of course only a very small number of the long-term tasks before us.

(This is a translation of extracts from an article entitled 'The Humanism of Science' published in Nauka i Chelovechestvo, II *(Moscow, 1963).)*

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THE MATHEMATICIAN'S TALE

David Vere-Jones

THE MATHEMATICIAN WALKS with his head in the clouds. His thoughts dwell in heavenly spheres and the gaze which he turns upon the world is like that of a child woken from a dream; spontaneous and untempered by worldly experience.

I have something of this feeling about my own impressions of the year I spent at Moscow University from September 1961 to July 1962. I was one of twenty-odd exchange students (for the most part students of language and literature) who had been selected by the British Council under one of the agreements for cultural exchange with the Soviet Union. After completing the year's study in Moscow, I returned to New Zealand, the country from which I had set out four years previously, and my original impressions are now filled out by reading, thinking, and talking. The experience of living for a year in the Soviet Union, mixing freely with the Soviet students, attending their lectures, sharing their lives, is not an easy one to assimilate. At times Moscow University and the whole of the Soviet Union seems nothing more than a vision inside a black box. For a moment the lid is lifted, I look in, and see people playing there, hurrying hither and thither, worried, happy, bored, in love, making mistakes, absorbed in their own lives. Now the lid is down, and it may never be lifted again, but in my mind they are still there, frozen in their final positions, absorbed still in the little details of their daily lives.

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MOSCOW UNIVERSITY is on a huge scale. The 'mech. mat. fak' (the inevitable Soviet-style abbreviation for the faculty of mathematics and mechanics) is one of the largest and most rapidly expanding of all the faculties—its annual *increase* runs to several hundred per year. These numbers may not be remarkable in view of the importance of Moscow in the Soviet education structure as a whole, but they made a strong immediate impression on a recent graduate from Oxford, where the mathematics staff would reach a total of no more than 50 or so. In Moscow there were more than a dozen members in the kafedra (or chair) of probability theory alone (my own special field), and seventeen kafedra within the faculty.

The Soviet student in mathematics covers a tremendous amount of material in his five-and-a-half year course. When he leaves school he has reached a standard roughly comparable with O-level school certificate; when he leaves Moscow University he will be a specialist as well trained as any in the world.

His first two years are taken up with basic material, starting from an introduction to the calculus, co-ordinate geometry, elementary probability

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theory, vector space concepts, the rudiments of set theory, and a first course in computer programming.

At the end of his second year he has to choose broadly between pure mathematics and mechanics (including fluid dynamics, aerodynamics, and the theory of elasticity). From then on his course becomes progressively more advanced and more specialised, until in his final year he is attending lectures and seminars intended primarily for research students. During his third year he is placed under one particular kafedra and allotted to one of the professors or docents who will be his supervisor. He and his supervisor then map out the final part of his course, choosing a balanced combination from the profusion of advanced lectures and seminars open to the senior student.

In addition to this basic material his programme includes a full five-year course in a foreign language, and a course in political economy, the principles of Marxism-Leninism, and the history of the communist party; set periods are devoted to physical education. The lectures are plotted on enormous time-tables which hang on the faculty notice board. The student's time is parcelled out as if he were still at school, according to a tight, full day's schedule five days a week, with a half day on Saturday for sport. This schedule continues until his final half-year, when he is released from a formal time-table to prepare a short dissertation. In the case of the most able students this may be a first attempt at original research, or, more generally, a survey or commentary on some recent work in his special field. He will also, in general, be expected to read a short paper to his seminar, again perhaps a report on some recent article relevant to the theme of the seminar.

The system is at its best in the upper stages, where the full benefit of the high staff-student ratio is felt. The seminar work gives the student an excellent introduction to mathematical research as it is in practice, with an idea not only of its possibilities but also of its disappointments and limitations. The staff took pains to encourage even the less able students to feel that they could contribute something of value to the work of the seminar. There were regular times once or twice a week when each professor came into the seminar in order to talk over the queries and problems of the students who were under his supervision. He might also invite senior students to discuss their work informally at his home, although it is hard to generalise on such a point, since in Moscow, as in any other university, the most important factor is the personality of the teacher. My overall impression was that the relations between the staff and students were good and informal, and that the staff had a feeling of personal responsibility towards their teaching duties.

As well as representing the Mecca of Soviet students, Moscow University was also the home of several thousand foreign students. They came from China, from Eastern Europe, from Vietnam, and from many of the uncommitted nations—India, countries in Africa, the Middle East, and Latin America. Some of the foreign students were taking the under-graduate course, some were postgraduates. My own natural companions,

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both in mathematics and in the Russian language classes, were post-graduate students from Eastern Europe. The East European students were on three-year scholarships leading to the Candidate of Science degree, through a course of considerable rigour. Apart from personal hardships (several of the students were married, and were separated from their wives for all save a few weeks of the year), and the difficulties of their own research, they were required to pass a proficiency examination in Russian, to sit their course examinations in Russian, and to write and defend their theses in Russian. Since we were all, by and large, facing the same difficulties (although mine were slighter), a sort of camaraderie developed among us, based on a tacit recognition of the points in common. We all knew (but rarely mentioned) that the division of the world into two camps worked to the personal detriment of each of us. Our political views were naïve, but we did not want to let political differences stand in the way of mutual friendship and assistance.

* * * *

TOWARDS THE END OF THE YEAR, our lessons in the Russian language developed into a sort of amateur forum, where we discussed plays, films, current events, or any other topic that floated into the head of our well-meaning teacher, and gave her the opportunity to correct our language errors. So we went to the films together, saw plays, read newspapers, and occasionally, as if by accident, we discussed politics. The following conversation is recorded in my diary. It arose from the topic ' cybernetics '. On that day there were three East German students in the group, and myself. The starting point was the question ' Can a machine think? ', then ' Can the ability to think exist without a corresponding moral sense?'

' Of course it can ', said Hubert.

' I don't agree ', I said, confusing the Russian word for moral with another word meaning ' sensuousness '.

' Wait ', cried our teacher, ' wait. Hubert says that great intellectual capacity can exist without moral sense. Why, Hubert?'

' Why . . . because it can. Such people exist.'

' Who, in particular?' I asked.

' Well . . . I had in mind the heads of governments of capitalist countries.' Hubert's long, childish face became very serious as he explained his thoughts. ' Leaders of governments must be—well—men of pretty high intellectual capacity, I should say, in any country."

' You haven't seen the government of New Zealand ' (laughter).

' But they can have no moral feelings. I mean if they permit the explosion of atomic weapons, as a result of which people will die, food will be poisoned . . .'

The old topics coming up. Poor old capitalist countries. What is the use of explaining?

' I must say I think you're right, only I don't think it's fair to say just " capitalist countries ". I think the trouble with the world today is

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that the leaders of *all* governments have no moral feelings' (more laughter).

So the discussion continued. Hubert reminds me of my younger brother. He has a long, serious face, unwrinkled by experience, although he is almost as old as I am, and already married. Anton does not enjoy politics. He is the most intelligent of us, knows Russian the best, but is perpetually in a state of slight bewilderment. His mind works along its own peculiar rails, sentences fly out at random, the association hidden to all save himself, to whom, no doubt, they are quite inevitable. Finally, there is Hermann, with a grim, clamped-jaw expression, and gimlet-blue eyes. Words are squeezed out of him as if they had to pass through a mincing machine. They echo hollowly round the room, a sequence of pure germanic sounds, bent and riveted around the Russian form.

* * * *

THE UNDERGRADUATES AT THE LECTURES seemed very much younger, although most of them were in their final year. In many ways they still behaved, and looked, like overgrown children. Much of the teaching was carried out in class-room style. There were set exercises each week, and one of the lecturers had the habit of choosing a student at random, sending him up to the blackboard, and asking him to work out there one of the last set of exercises, or to explain some key point of the previous lecture. Fortunately, foreign post-graduates escaped this inquisition, so that I was able to enjoy my greater maturity in tranquillity and peace of mind. The students were also very young in comparison with the students of language and literature in whose zone I lived (by error, since I should have been given a room in the zone for students of mathematics and physics). This comparison never struck me until after I left Russia, but it seems to me now that it illustrated the operation of the principle of 'polytechnisation', that students should complete a period of outside work before they are admitted to the university. Certain subjects have priority, however, and are more or less exempt from this requirement, and in the forefront of these stands mathematics. Thus most of the mathematics students enter university straight after leaving school, at the age of eighteen or so. On the other hand, language and literature come well down the list, and most of these students were much older, some indeed (ex-servicemen) in their thirties and forties.

Our seminar had the disadvantage of taking place at 6 o'clock in the evening, a time when I was already exhausted by a day in an overheated, overcrowded, comfortless skyscraper, and more concerned with food than with the application of probability theory. It formed part of the evening schedule, designed both for part-time students working during the day and for the full-time undergraduates. Its thirty-odd members were made up of approximately equal proportions of undergraduate students, post-graduate students, and engineers and other

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personnel from outside the university. It was led by a professor and two deputies, the equivalent of lecturers. The Russians seemed extraordinarily patient. For two hours they would listen earnestly to a detailed description of an involved queueing theory problem which had arisen in some industrial application, or to a fifth-year student attempting to explain a difficult research paper, constantly interrupted with advice and supplementary information by one or other of the two enthusiastic young lecturers running the seminar. One day, in a particularly savage mood of boredom, I occupied myself in writing my diary instead of joining in the analysis of a system of machines subject to random breakdown for random periods of time.

In the Seminar; An Anecdote in the Russian Style

. . . No, no, it is very kind of you, but what is the point of writing? The artist must describe the essentials of life, love especially, and where do these touch the seminar? Looking round, I see only fear, boredom, incomprehension. Next to me is an Indian, mournful, impeccably dressed in a clean white shirt and tie, neatly pressed trousers, jacket, and glossy black hair. He is afraid he is going to fail his examinations. In front of him sits Ludmilla from Baku, dark and heavy-faced. Ali-Fattah, also from Baku, is our expert. Small, dark, and very proud, he is often called upon by our supervisor, a very knowing man, to help with a question of reference. On my other side sit the non-experts, the students. One, a Russian, and not handsome, sits reading a book under the cover of the desk. In front of him a quiet little man from Vietnam with large glasses, a bulging forehead, and a thin body, stares intently at the blackboard. What is he thinking? Nobody knows. He has no acquaintances. One other group I must mention. The Military. Yes, there are real Military in our seminar; they come in uniform, and one of them is even quite old, with silver hair, and a row of ribbons on his chest. They usually sit together, and talk among themselves, but not to anybody else. Only Ludmilla, who is a very quiet, sympathetic, and kind girl, though, I am afraid to say, ugly, seems to know them, and occasionally gives them references or confers with them on some mathematical problem which they seem to study together. The most remarkable thing about these Military is their politeness. They always rise to their feet or raise a hand when they want to ask a question, even the old one with silver hair and ribbons, and they always address our supervisor by his Christian name and patronymic (as is polite) and wait for him to finish a sentence before speaking. . . . Quite unlike us students, who call out rudely 'X!', interrupting the lecturer in the middle of his sentence so that he has to turn to us and ask us what is the trouble, and then we can repeat, usually two or three in chorus:

'X! You have missed out an X in the last expression!'

'Oh, oh, of course', he has to say, 'Thank you very much'; and you can see that he is really cursing himself for having made such a slip, and thinking to himself how rude and uncivil the students are in this seminar . . .

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THE INTERESTS of our mathematics professors extended beyond the confines of mathematical research, embracing broad cultural concerns, and a sense of responsibility to the community. Khinchin had written poetry as well as mathematics, and his style has a beautiful clarity, elegance, and simplicity. Kolmogorov, although more turgid in style, shows the quality of his thought in the avoidance of irrelevant details, and persistent emphasis of points which lead to the nub of the problem.

Both had spent some time as school teachers, and made numerous contributions to school mathematics in the form of text-books, popular expositions, essays, and articles. It is, of course, very difficult to ascertain their precise influence on Soviet mathematical education, but I would like to examine a few particular ideas expressed in their writings (particularly by Kolmogorov), and a few particular features of mathematics teaching in the Soviet Union where it seems to me that their influence has been important.

The two key themes which illuminate his own contributions to mathematical education are expressed by Kolmogorov in the following extract from a recent article in *Izvestiya* ('Are scientific schools necessary?', 28 October 1962). In discussing the training of advanced students, he writes: 'In suggesting a research theme for a diploma student or post-graduate, the supervisor must think not only of the objective significance or relevance of the theme; he must also ask whether work on this theme will stimulate the incipient scholar—whether it will be within his powers, and yet demand the maximum possible exertion of his skill. It is very sad, however, when in the pursuit of these subsidiary aims, the most important—the feeling of participation in the forward movement of science, the feeling of personal responsibility and concern over the choice of a direction of work that will contribute to the real progress of science—becomes clouded in the mind of the young scholar or his supervisor.'

Kolmogorov himself had a particularly sure sense of the important movements in mathematics. His own work in probability theory is evidence enough of this. But it came into play also in his work as a professor and (for a time) as dean of the faculty, when he was able to initiate and encourage the development of new courses. One of the most important innovations was the exploitation in undergraduate teaching of a modern branch of mathematics known as functional analysis. Mathematical progress is not merely forward motion: a mathematical discovery of real importance may have as its greatest value the unification of large tracts of hitherto unrelated material. Such has been the role of functional analysis. Although it is clear that any such discovery must have potential teaching value, it is a daring and original mind that can first bring it down from the realms of higher mathematics to a level where it can be used as the basis of an undergraduate course. This was Kolmogorov's achievement in functional analysis, and the resulting text-book has been widely acclaimed in many parts of the world.

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The other subject which has been developed to an outstanding degree in the undergraduate courses at Moscow, and which has been equally important in view of its immense range of application, is probability theory itself. This was one of the first features which struck me when I arrived in Moscow. The kafedra in probability theory is one of the most important in the faculty; it ran many courses at all levels, from an elementary introduction to probability theory to extremely advanced and specialised courses for final year students and post-graduates. Even the most specialised courses were attended by audiences 40 to 50 strong. This is in marked contrast to the situation at Oxford, from which I had just come. Even allowing for the difference in size of the universities, and the relative importance of the mathematics faculties, one might expect a comparable course at Oxford to attract perhaps eight or nine students. In fact there were no comparable courses and probability theory itself, relegated to a small corner of one of the finals papers, is usually omitted by students with more immediate aims in view. Until very recently, probability theory was little better off at Cambridge, where its teaching was largely confined to the statistical laboratory, a peripheral part of the university structure which had little or no power to influence the tripos course or the examinations.

If we turn to school mathematics, we find on the Soviet horizon the same problems as have long overshadowed our own. Mathematicians are needed in ever greater numbers in industry and in all branches of science and technology. Yet the teaching of mathematics in schools is often carried out by teachers with poor qualifications and little understanding or appreciation of mathematics. Children may be badly trained, or, what is worse, turned from mathematics to other subjects which are better taught. Kolmogorov has reiterated the need to stimulate the child's curiosity, to provide him with interesting and thought-provoking material in addition to the somewhat limited requirements of the school syllabus. This was the guiding motive behind the formation of the school 'mathematical circles' and the 'mathematical olympiads' which are their culminating activity. These annual competitions have been held in the Soviet Union now for more than a quarter of a century. They have passed beyond the stage of an interesting experiment, and become an established part of the school programme, designed specifically to encourage, stimulate, and select the more mathematically gifted children. The circles meet once a week, usually in the local university, where they are run by junior members of the mathematics staff. The topics they discuss may arise spontaneously from problems and questions brought in by the children, or they may follow a more formal course—there is a whole series of 'junior texts' available specifically for this purpose, with titles such as *Convex Figures, Geometrical Transformations*, etc. Topics are chosen from outside the regular school syllabus, and are designed to stimulate the child's curiosity and to direct it towards important ideas which will recur at higher stages in his study. At the end of the year, the circles organise local

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olympiads, one section for each of the last five classes at school. The winners go on to take part in the provincial contests, and finally in the Grand Championship All-Union bout, from which is chosen 'the best mathematician of the year' in each section. The final questions do not require much formal mathematical knowledge, but they do need a great deal of mathematical ingenuity. They form a complement and a complete contrast to the state examination for entrance into the higher education institutes, which is based on the mastery of a straightforward syllabus and a few fundamental mathematical techniques, such as the ability to manipulate simple trigonometric functions, solve quadratic equations, factorise trinomials, and so on.

* * * *

THIS LEADS ME TO A QUESTION very hotly debated in the West at the present time; what is the proper constitution of a modern school syllabus in mathematics? In many countries in Western Europe, and in America, ideas have been put forward, and indeed tried out—one might quote the Southampton scheme in England, where a group of schools (Winchester included) is using a new syllabus with its own special papers for school certificate—which mark a radical departure from the old mathematics course. It is remarkable that these ideas find hardly any counterpart in the Soviet Union. The underlying reason is the same in both countries—the explosive growth of the applications of mathematics since the war. But whereas in the West the idea has taken root that a satisfactory solution can be found only in terms of a drastic revision of the school syllabus, in the Soviet Union, the emphasis remains (at least for the time being) on providing basic technical skills. The only conceivable movement which could be cited as a parallel to the developments in Western Europe is the polytechnic movement with its call for 'closer relations with real life'. But despite the importance of this movement for Soviet education as a whole, it does not seem to have affected greatly the teaching of mathematics. Greater use is to be made of practical demonstrations; examples are to be chosen from contemporary industry and agriculture; the syllabus is to make some attempt to meet the demands of the higher education institutes for new material in their entrance examination. But by and large the syllabus stands as it was. Soviet teachers seem to put their faith in extra-school activities, such as the mathematical circles, to provide the better students with the stimulus that is lacking in the basic course.

Kolmogorov's own view is blunt but hardly radical. In a second article, 'The Quest for Talent' (*Izvestiya*, 7 April 1963) he discusses the problem of finding and training the necessary mathematical talent. The main difficulty at present he ascribes to the inadequate qualifications of mathematics teachers in many secondary schools. He goes on to say: 'If we seek the means to find *all* those school children who could most successfully choose mathematics as a career, there is no other path save through extended systematic work to raise the standard of

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mathematics teaching in all schools; the printing of mass editions of popular literature on mathematics, supplementary to the text-books; and the reading of popular lectures. And, after this long training, the organisation of olympiads.'

* * * *

MANY OTHER QUESTIONS ARISE. How far do the universities co-operate with outside institutions in solving particular technical problems and in developing research themes which have practical as well as theoretical importance? What is the present role of statistics in the Soviet Union, and, in particular, are its applications in agriculture and economics still the subject of party suspicion? How far have the Russians developed the use of high-speed computers, and what steps are they taking to train the specialised personnel needed to programme and service them? How far, in general, have mathematical techniques penetrated into Soviet industry, agriculture, and economics? These questions were all raised by particular events in my own experience, but I shall have to leave them here unanswered. I should like to conclude in Russian style, with a tribute and a toast. When I went to the Soviet Union I was a very reluctant mathematician. Two years previously I had very nearly deserted my D.Phil. thesis in favour of a vagabond life on the stage, and the chief virtue of the British Council scholarship in my eyes was that it led away from the rather uninspiring teaching appointments which seemed about to fall to my lot in England. I returned with a new concept of the mathematician, and a new understanding of his work and aims. The mathematicians I met in the Soviet Union were men of high principles and inspiring teachers; their pupils were uniformly friendly and hospitable. If, as seems inevitable, the present progress of society will subject the Soviet hierarchy to gradual infiltration by the mathematician and his minions, I can look upon this prospect only with equanimity. In fact, here's strength to his arm!

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EXCHANGE SCIENTIST IN LENINGRAD

Hans Kuebler

IN 1962 I worked as an exchange scientist at a Leningrad technical university which specialises in forestry and wood technology. I was engaged in a special piece of research into the drying of wood. In addition to my theoretical studies, I conducted tests in the laboratories of the university and in two enterprises of the timber industry. My hosts found me lodgings in a hostel for unmarried scientists from the Soviet Union and various East bloc countries. All the people I met were open and friendly. I managed to talk to them in Russian and in this way I really learned something about the conditions there.

My host university had an astonishingly large number of students—more than 4,000 in fact, even though there are other universities in Russia which specialise in the same subject. It was similar in other specialised branches. In 1961 more than two and a half million men and women were registered as students, i.e. 12 per cent of the population in the relevant age groups. Even more significant perhaps was the fact that among these very large numbers the percentage of those studying technology and the natural sciences was much higher than in Western countries. According to the published statistical data the USSR had at that time three times as many students of technology as the USA. I wondered whether the Soviet Union really needed all that many academically trained technologists and natural scientists. I was also struck by the fact that as many as 43 per cent of these students were women and I thought that it was rather pointless to train so many women in a field in which they would work for only a short time. However, I discovered that practically all Soviet women carry on their profession even after marriage, partly at least because the low real income of their husbands compels them to go on earning. Soviet society evidently has a large capacity for the absorption of academically trained people. There are a number of reasons for this; the main task of the state-owned enterprises is to meet their plan targets—their profits and losses are secondary considerations. The achievement of the plan targets is however frequently hampered by the chronic shortage of staff, and there is a tendency therefore to employ even unsuitable people. Work is done by academically trained staff which could just as well be done by the less highly trained. Managers have no incentive to save on expenses for personnel by doing the work themselves or by delegating it to less highly paid employees.

Since social advance in the Soviet Union is practically impossible without university training, and university studies cost nothing, it is not surprising that in the summer of 1962 approximately seven million young Soviet citizens tried to enter a university. Entrance examinations

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are held during the academic summer vacations. Prospective students have to pass examinations in Russian, mathematics, physics, chemistry, history, geography, and one foreign language. Together with the necessary preliminaries the examinations take two to three weeks. Entry into a university depends on the result of the examinations, but there is a clear preference for youngsters who have done some practical work, a preference reflected in the regulation that eighty per cent of new university entrants must be chosen from among those who have done at least two years' practical work or military service. Only twenty per cent are admitted directly from school, and the competition among these school leavers for university places is very keen. On the average the university accepts one candidate out of every three. Those who fail are given a chance of trying again in the following year. There is no point in applying simultaneously to several universities as all university examinations are held at the same time.

THE students live in barrack-like blocks, with boys and girls occupying different floors. At my own host university rooms have to be shared between three to eight students. The living rooms are equipped with plain furniture and with radio loudspeakers which can be switched off. Most students take their breakfasts and suppers in their rooms; they brew tea and eat plain food; but the hostel also has a cafeteria where breakfasts and suppers can be bought. The huge self-service canteen of the university serves cheap lunches; its hygienic standards are not very high and the quality of the food is often poor. The Russians have a long tradition of good cooking, and the Russian students at my university did not like the canteen food any better than I did. Yet they put up with it for years on end, and their health does not suffer.

Both male and female students spend a good deal of time on sports, for which ample facilities are provided in the university sports grounds and the smaller playing fields of the hostels. Most of them play volley ball or table tennis; others train in athletics, partly at least in the hope of becoming eligible for inclusion in a sports team travelling abroad. Hardly any of them seem to be distracted from their studies by strong personal passions such as driving or love affairs. Even among the teaching staff only very few own cars.

Most of the students of my host university received state grants which just sufficed for their most essential needs. Some of them were very poorly dressed; but their suits, dresses, coats, and shoes were in good repair. The sons and daughters of socially high-ranking parents made no attempt to disguise their background. They liked to display their prettier or better quality clothes or shoes, imported from the bloc countries. The very large number of poor students evidently felt no kind of social pressure from those who were better off. The girl students, like their counterparts everywhere else, were chiefly concerned with their looks, and although it was impossible to find good fashion journals in Leningrad and difficult to buy pretty dresses, they nevertheless dressed

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well and in modern style. They adopted the latest Western fashions almost as quickly as women in the Western countries. The realm of fashion certainly did not appear to be divided by any sort of iron curtain.

STUDENTS have to work hard. Attendance at lectures and seminars is compulsory, and examinations in three to five obligatory subjects are held at the end of each year. The study courses cover five years in all. The curricula are worked out in Moscow in accordance with the changing requirements and wishes of the Government. From 60 to 70 per cent of the time is taken by the subjects in which the students are specialising. During the two months summer vacation the students do practical work in the field of their future profession. When I was there, even after term had started, they had to help for two weeks with the potato harvest which otherwise would not have been completed. The students had later on to make up for the time thus lost from their studies.

In their last year, students have to use the time not occupied by lectures to write a diploma thesis on a practical topic. Later on, as the crowning event of their student life, they have to defend this thesis in public. This public defence is accomplished in three stages. First, the students have to report on their work before an examination committee; second, they have to reply to criticism of their work by two of the examiners; third, they have to answer questions put by members of the committee. When all this is completed, the committee awards its marks. Some five per cent of the students fail to pass. The young women engineers I knew who had passed were received with flowers by their girl friends; the young men celebrated by buying vodka and getting thoroughly drunk.

Only 45 per cent of the Soviet students, however, have the chance to lead this sort of life. The remaining 55 per cent have a much harder time. They pursue their studies in evening or correspondence courses while doing a full-time job. They are part-time students either because they had failed to pass the entrance examinations for full-time students or because they wanted to have more money than the grants available to full-time students. The institute supervising the correspondence course students supplies them with material and marks their written work. Their personal contact with the supervising institute is restricted to two to three weeks a year when they attend in order to take part in exercises or to sit for examinations. Evening students, working in the university city itself or in its immediate neighbourhood, attend evening classes for sixten hours a week. Young people are encouraged to combine studies with earning their living, partly because this saves the State money and partly because it provides an opportunity for students to adapt their studies to practical requirements. The life of these part-time students is extraordinarily hard. They have to master the same kind and amount of material as the full-time students, and they have only one additional year for this purpose. Some of them put up with

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astonishingly harsh conditions. To study and also do a full-time job is much more difficult in the USSR than in Western Europe because of the ever-recurring shortages, the poor housing conditions, the non-existent consumer services, the lack of household gadgets, and the very poor service in the shops.

Stimulated perhaps by the example of the evening and correspondence course students who combine their studies with practical work, my host university gave its full-time students the opportunity to participate, over and above their normal studies, in certain research projects. The subjects of the diploma theses were in such cases invariably chosen with a view to their practical economic importance. But even during their first years students are directed towards productive work. This is done in part by means of voluntary 'scientific student societies' whose members, under the direction of one of the lecturers, undertake small-scale research projects. The societies hold annual meetings during which the students report on their findings. The best papers are published and their authors receive awards.

THE first objective in the scientific career of a Soviet citizen is the degree of 'candidate of science'. In order to obtain it university graduates apply, after a minimum of two years of practical work, for enrolment in a university post-graduate course (*aspirantura*). For this they have to pass competitive entrance examinations in a foreign language, in the history of the communist party, and in their special subject. Those with the highest marks are then enrolled in the three-year post-graduate course as would-be candidates (*aspirants*). They receive grants amounting to about three-quarters of the salary they had earned at their previous post. In their first year they learn more about their special subject and study a foreign language largely by translating specialised scientific writings. They also study 'philosophy', i.e. the essentials of Marxism-Leninism, but are left in ignorance of the many arguments against this particular philosophy. I had many discussions with post-graduates about their philosophy and was again and again surprised to discover how ill-prepared they were for any critical counter-arguments.

In their second year, aspirants start work on a thesis and participate in the work of the faculty. The third year is devoted exclusively to the thesis, a precis of the thesis is printed, and this they have to defend in public. Those who succeed receive the degree of 'candidate of science'. Many post-graduates, however, fail to finish their work within the three-year limit. They are given the opportunity to complete it later, but in rather more difficult circumstances, while earning their living, and to defend their thesis at the university during their holidays. This forbidding prospect acts as a powerful stimulus to diligence.

Certain people can get the degree of 'candidate of science' without taking the post-graduate courses. They include research workers employed by universities and scientific institutes and graduates working

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in industry or agriculture. They have to pass the same examination as the participants in the post-graduate courses and have four years in which to write and defend their thesis. To help them with this they are given each year a month of extra leave over and above their normal holidays. The present intention is to make this method of acquiring a higher degree the normal practice in the future.

We all know that one good piece of research counts for more than a dozen average treatises. The ideas of a few outstanding men are of greater significance than the combined intellectual output of entire universities. The Soviet authorities have taken this to heart and provide their scientists with strong material and moral incentives to do their very best. The candidates of science have the opportunity to acquire the higher degree of a doctor of science and thereby a greatly enhanced social status. In order to acquire a doctorate, candidates have to write a dissertation which represents a genuine contribution to science. Most of them get their doctorate only in the fifth decade of their lives; their salaries are 50 to 100 per cent greater than those of the ' candidates '.

Other higher scientific degrees are those of a ' Corresponding Member of the Academy of Sciences ' and ' Member of the Academy of Sciences ' —the highest and financially most rewarding stage. It is the Academy itself, the highest research institution of the Soviet Union, which bestows this degree with the formal consent of the Council of Ministers of the USSR. Members of the Academy work in all sorts of different posts and institutions; many of them work in the Academy's own research institutes whose members have the best possible facilities at their disposal and are under no obligation to teach. Their status is reflected in the public respect which they enjoy.

ACCORDING to official statistics scientists receive the highest incomes in the Soviet Union. Moreover, they enjoy great prestige; scientific work is regarded as work of high moral value. For all these reasons practically every gifted Soviet youngster tries to become a scientist. The opportunities for education and specialised training are open to all, and thus the Soviet Union creates for itself an almost limitless reservoir of new scientific recruits. In such conditions the level of science is determined by the principle of selection.

The method struck me as intelligent. Would-be candidates are examined by commissions and have to defend their theses in public; the evaluation of their work is carried out by the scientific councils of the faculty or by specially appointed commissions. The scientific councils include the professor and other teachers of the faculty concerned, scientists from other institutes, as well as representatives of the authorities and of industry. The evaluation of a doctoral dissertation is the task of the scientific council of the university, which includes the rectors, doctors, deans, and notable scientists from other institutes. In theory, it seems possible that members of the scientific councils might deliberately fail a highly gifted would-be candidate so as to eliminate

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a potential rival. In practice, however, this is hardly possible, since the theses and dissertations have to be publicly defended and the party exercises a sharp vigilance. In the case of a doctorate it is moreover necessary to obtain the consent of the ministry concerned with the industry in question.

Employment contracts of scientists are limited to five years; this limit was imposed in order to maintain scientific progress at the universities, to uphold the principle of merit, and to stimulate ambition. At the end of the five years the contract can be renewed provided that at least 50 per cent of the members of the scientific council agree on this in a secret vote. If and when they fail to do so, the post is advertised as open to competition. Applicants have to supply testimonials and a list of their publications. The eventual selection depends, however, mainly on the nature of the particular research project which the applicant proposes to undertake. I gained the impression that this form of competition is not very popular among Soviet scientists. Like academic staff elsewhere, they seem to prefer security and a quiet life. The competitions for scientific posts are said to have been instituted, not by the university teachers themselves, but by the party or some ministry or other. In practice, on the other hand, things are not always as strict as they appear. The scientific councils rarely remove any incumbent from his post.

Since Soviet research is meant to serve the ' victory of communism ', practical problems loom large in the research programmes of the universities. Most favoured are those projects which promise to lead to definite savings in materials or labour, or to other important tangible advantages. The institutes of the Academy of Sciences enjoy greater freedom than the universities; they are allowed and, indeed, supposed to engage also in fundamental research even when it cannot be established in advance that the project will lead to any practical application. Experience has taught us that the truly great leaps forward have their origin in fundamental research.

The success of scientific work depends, no doubt, in the first place on the quality of thought that enters into it and on the general atmosphere within which research is conducted. It also, however, depends on material conditions. In some fields it is impossible to make progress without expensive equipment. Material conditions at the Leningrad university were very uneven. The buildings were old and in bad repair. The furniture, too, seemed to have come down from the days of Tsarism. The rooms serving as offices and laboratories constantly reminded me of the acute housing shortage of the Russian cities. Only a very few men at the top—say, from the dean of the faculty upwards—had their own separate studies. There was, on the other hand, no shortage of any essential research equipment. Modern instruments of measurement were just as plentiful as they are in Western scientific institutes. The instruments resembled the best known German types much more closely than the North American types. Many high quality gauges had been

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imported from the East European countries. There was a shortage of some of the smaller auxiliary instruments and materials, but not of any that were really essential. The lean years of the past have taught the Russians the art of improvisation, and they continue to practise it. On several occasions, for instance, I saw them put the bare cable ends into power points instead of using electric plugs. The libraries were well equipped. They stocked not only the relevant publications of the Eastern bloc but also all the important scientific books and journals of the Western world. There were some gaps among particularly popular Western standard works which had been lost. Because of shortage of foreign currency it was forbidden to buy such books privately.

In my own field, the field of wood research, the achievements of the Soviet research workers appeared to me to be generally good but not altogether satisfactory considering the large number of people engaged. Western European countries have achieved similarly noteworthy results with a much smaller staff of research workers. North America, which has invested about as much in wood research as the Soviet Union, has more to show for its efforts. This does not mean that Soviet research is bad; it reflects the low technological level of the Soviet timber industry. Whenever research is geared to the practical problems of an industry it invariably adapts itself to the actual level of that industry in the given country.

BEFORE my stay in the Soviet Union I saw frequent references in its press to the 'leading role of the communist party in all spheres of public life'. The communist party as such did not figure on the official staff list of my host university. Apart from the rector, there were vice-rectors for research, for teaching, and for administration, but there was no vice-rector for politics or anything of that sort. Nevertheless, the rector's powers were strictly limited. He was not entitled to give me permission to visit my embassy in Moscow or to recommend that my wife be permitted to visit Leningrad. In all such matters I came up against a secret kind of authority which alone had the right to make decisions but with which I was never able to make contact. This secret authority was presumably the party secretary at the university. Otherwise, the party acted in matters concerning the university not altogether secretly, but certainly also not publicly.

Approximately half the scientists working there were party members. I was never able to discover their exact number. I never saw membership lists, and the party members wore no badges. The party organisation was adapted to the structure of the university. Departments with several party members had party cells which together formed the party group of the faculty, with its own bureau. The various party groups were combined in one university organisation under the leadership of a party committee. I gathered that the party committee and the party groups were the most powerful authorities at the university. If and when a party authority objected to a decision made by a prominent

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university official, this had the same effect as a court judgment. In one university the komsomol, which included approximately 90 per cent of all students, advised the rector to send down a 'lazy and dissipated' student. The rector immediately acted on this advice although no university statute made this obligatory. He had no choice in the matter. The party would certainly have upheld the komsomol decision, and the party was stronger than the rector. Nor, as I was able to ascertain in a number of cases, did the party confine itself to supervisory functions; it took the initiative in working out directives and in conveying them in a binding form to the university staff. Usually direct party instructions to the university directorate were superfluous, because leading members of the directorate were themselves also party members.

I had been wondering whether party members received any preferential treatment in examinations or in the appointment of new staff. In theory party members are supposed to shoulder more onerous duties than other people and enjoy no special privileges. I met some such idealists in Leningrad. They said that if party members were given preferential treatment this would be a direct inducement for opportunists to join the party. They also pointed out that many leading scientists had reached their position without party membership. Discrimination against highly qualified non-party people, they said, would lead to a waste of valuable talents, which could not be tolerated in view of the Soviet Union's economic difficulties and its great plans for the future. But from conversations with acquaintances I gathered that, everything else being equal, party members will be given preference in competitions for university posts.

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ASTRONOMY IN THE USSR

W. H. McCrea, F.R.S.

ASTRONOMY IS THE MOST ANCIENT of all the sciences and it has the longest and strongest tradition of international cooperation. A good example of the observance of that tradition in modern times is in fact provided by the history of the first great modern observatory of the Russian Empire. It was opened in 1839 at Pulkovo near Leningrad (then St. Petersburg) and had as its famous first Director F. G. W. Struve (1793–1864) who came from Holstein and had been Director of the Observatory of Dorpat. He paid several memorable visits to England, served on a committee for the improvement of the *Nautical Almanac*, and took a decisive step towards the international recognition of the Greenwich prime meridian. Ever since, Pulkovo Observatory has played an important part in the international exchange of astronomical information and in internationally agreed programmes of investigation. Astronomy, together with the related science of geodesy, was also the first science in which permanent international organisations were established, culminating in 1919 in the International Astronomical Union (IAU) as we still know it. Since 1935, the Soviet Union has been a prominent member-state, adhering through the USSR Academy of Sciences. There have been continuing participation in common programmes, and many exchanges of visits between the ever-expanding observatories in the USSR and other observatories all over the world; in 1936, the USSR received numerous expeditions from abroad to observe a total solar eclipse from stations in Siberia; since the second world War, there have been several occasions when astronomers from many countries were invited to the inauguration or re-opening ceremonies for observatories in the USSR; in 1958, the IAU held its tenth General Assembly in Moscow; at the eleventh General Assembly in the United States, it elected as President Academician V. A. Ambartsumian, Director of the Byurakan Observatory in the Armenian SSR; Ambartsumian is to preside over the twelfth General Assembly in Hamburg in 1964.

Astronomers all over the world, therefore, are as well acquainted with their Soviet colleagues as they are with other colleagues. Indeed, it seems incomprehensible to an astronomer when, as still occasionally happens, scientists in some other field regard a relatively small amount of personal scientific collaboration between Soviet and non-Soviet colleagues as a remarkable novelty.

While astronomers do get to know each other and each other's work, it is nevertheless regrettably true that they mostly do not get to see each other at work in their own institutions. One reason is that there *are* so many meetings, such as those of the IAU and its symposia, at which an astronomer can meet colleagues, from widely separated centres, who share his special interests, without his having to travel round those

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centres. Besides, conferences even amongst astronomers have to be arranged where there are conference facilities, and a place where these exist is usually not a good place for an observatory. So, when astronomers meet in any particular country, they often see very little of the country's observatories. There are also obstacles presented by language difficulties, expense of travel, and administrative complications. Another reason is just plain inertia: after a few interchanges of a particular sort, further similar ones become almost routine—but there have to be the pioneers who get things moving. Of course, there is what appears to non-astronomers to be quite a lot of international coming and going between observatories. Most of this, however, does tend to remain with relatively few institutions that have an established tradition for it. Everyone who has taken part in these interchanges seems to be convinced of their value and to consider that more of them are desirable.

In 1960, I had the privilege of spending two months in the USSR as a Royal Society exchange visitor to the USSR Academy of Sciences. The Academy arranged for me to spend my time in visits to several astronomical institutions. (Although I travelled thousands of miles in the USSR, this was mostly by jet aircraft and not much time was lost in this way.) I gave lectures at most places I visited, but the main purpose was to see the work in progress and to discuss scientific matters in an informal way. In fact, in each place, I was for a week or two to become a resident member of the scientific community. Very few foreign astronomers have had a chance to make a visit of this sort. Quite a large number of British astronomers have visited all the institutions I saw, but almost all their visits have been to mark particular occasions, or in connection with particular meetings or missions. During my own visit, I met the first astronomical visitor under the corresponding exchange scheme between the National Academy of Sciences of America and the USSR Academy. I met also the first American astronomical visitor to carry out a programme of work at a Soviet observatory. (In passing, I ought to say that he told me he knew no observatory in the world where he would be treated so handsomely. He was granted the use of a very special telescope for a couple of days every week during the six months of his visit. On these days, he took charge of the instrument and of its associated staff; he planned his own programme, and the Director and other colleagues worked as his assistants. On the other days, the arrangements were reversed. It seemed to be an ideal way of exchanging ideas.)

Many well-known Soviet astronomers have visited various British institutions for a variety of scientific purposes, but their visits have for the most part been no longer than a week or two at a time. A beginning has been made in getting younger astronomers to work in Britain for longer periods. A radio astronomer from Armenia and one from the Crimea have recently worked at Jodrell Bank for visits each of a couple of months duration. Besides this, it should be recalled that Sir Bernard

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Lovell and his colleagues at Jodrell Bank have rendered important service to Soviet investigators (as well as to the Americans) in tracking their deep-space probes.

I have been asked to write something that will convey the 'feel' of Soviet astronomy, rather than a systematic assessment. I am glad to try to meet this request. For a matter-of-fact account of Soviet astronomy, while it would have a lot to record, would read much like an account of astronomical work in other parts of the world; it would serve little purpose in a non-astronomical journal. Readers may, however, like to savour the atmosphere in which the work is being carried out, if I can muster the skill to convey it.

Background

AT THE END OF THE SECOND WORLD WAR there was scarcely a single sizable telescope left intact in the USSR. The great Pulkovo Observatory was in the line of fire between the armies in the siege of Leningrad, and it was obliterated. In one of the present offices, they show a shapeless lump of metal; it is all that was found of the telescope-mountings after the fighting was over. Some of the optical parts had been removed to safety and were restored to use in due course. But there had also been, 1,000 miles away in the Crimea, under the control of the Pulkovo Observatory, a famous 40-inch reflector made in England. A German soldier shattered the mirror with a pistol shot; the mounting was removed, only to rot in a German railway siding where it was found after the war in a useless condition.

The Soviet Union began its existence in 1917 as in some respects an almost medieval country. It set out to become a great modern power in the shortest possible time. It could achieve this only through a concentration of effort upon science and technology. But again, after the devastation of 1941–45, it had to re-build itself in what was being called a scientific and atomic age. So, more than ever, science and technology were in the forefront. I think it is not generally realised to what extent the USSR had to make a fresh start less than 20 years ago. Why, in the general attention to science for urgent utilitarian purposes, astronomy was treated rather well instead of being sacrificed for the sake of more applicable subjects, is something of a mystery. It must have been partly because the USSR had good astronomers, and because their science had suffered so cruelly. But I think the treatment was inspired principally by the judgment, or the instinct, that, if physical science is so important, then it is only sensible to study as much as possible of the physical universe and not only the little bits of it that can be got into a physics laboratory.

However that may be, the Pulkovo Observatory was re-built in a time that was surprisingly short compared with anything like it in other countries and considering the other calls upon resources. I say 're-built'

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because the main building is in the handsome classical style of the original, but all the other buildings are designed to house new instruments.

Soviet astronomers also knew the need for instruments of great light-gathering power in places where climatic conditions are more favourable than they are near Leningrad. They decided to build a great modern astrophysical observatory in the Crimea. The largest telescope there, which is also the largest in Europe, is a 120-inch reflector. In the main, and quite frankly so, it is a copy of the second-largest telescope in the world, that at the Lick Observatory in California. Experience elsewhere in the world shows that it was eminently sensible to adopt an already worked-out design in order as speedily as possible to enter the field of big-instrument astronomy. Other similar cases will be mentioned below.

The result of these developments is that Soviet astronomy is now equipped entirely with modern instruments. The tragedies of the past have been turned into a blessing for the present generation. And if there is scarcely any telescope more than about 15 years old, the majority of the astronomers are not more than about 30 years old. The number of astronomers must be some 20 times what it was 15 years ago, and the recruitment has naturally been of young scientists.

Here I am bound to write a word of admiration for the Directors of all the great observatories of the USSR. World astronomy, as well as Soviet astronomy, is fortunate indeed that men were found to make and to match the opportunities of recent times. They have had the vision of what could be done, and they have succeeded in persuading and inspiring their colleagues in the Academy to support them. They have accomplished great feats of organisation at home. At the same time, they have effectively represented their country in many international astronomical affairs. They lead their teams with much human kindliness, and their teams give them loyal service. Perhaps above all, these directors have remained distinguished working scientists.

Space Science

ONE IS NATURALLY INTERESTED in the relations in the USSR between optical and radio astronomy on the one hand, and space-research on the other. The first thing to say is that the major achievements in Soviet space-research have so far been mainly in its technology rather than in applications of the new technology to astronomical investigations. Astronomical advances may be expected during the next few years; it is understood, for example, that the USSR plans to place a manned 36-inch reflecting telescope in orbit at a height of 100 to 200 miles above the earth's surface. But, while cooperation between astronomers, space-scientists, and space-technicians is reported to be excellent, there is no indication that support for astronomy in general is specially linked with expected developments in observations from space.

One spectacular achievement of Soviet space-science was, of course, the photographing of the back of the Moon. As is well-known, the back

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of the Moon was filmed from a space-vehicle, and the films were televised to the earth when the vehicle returned to the earth's vicinity. The pictures were recorded by several receivers. As received, they were extremely difficult to interpret as a result of the many processes involved in obtaining them; only astronomers with great experience of the properties of photographic emulsions could decipher them. It is interesting that original sets of the pictures were sent to three observatories in the USSR to see what they could make of them; the published results were the outcome of the three independent studies.

Organisation

ALL FUNDAMENTAL SCIENTIFIC RESEARCH in the USSR is administered by the USSR Academy of Sciences. In this capacity, the Academy takes the rôle rather of the DSIR in Britain than that of the Royal Society. It operates through an Astronomical Council. The President and two Vice-Presidents of the Council are internationally-known professional astronomers whose service on the Council is part-time work. The Council has to satisfy itself as to the efficient running of all the astronomical institutes of the Academy and has to make the needed financial recommendations. It organises a certain amount of work directly, such as nation-wide satellite tracking-stations. Also it performs certain centralised services such as arranging conferences, collating and editing reports for transmission to international organisations, and looking after astronomical visitors from other countries. It seems to perform its varied functions with tact and efficiency. So far as my observation went, any individual astronomer has complete freedom in choosing his line of work; indeed, I saw one or two cases of rather pleasing toleration of the foibles of a colleague.

Astronomical Institutions

I NOW GIVE A FEW NOTES on some particular institutions with which I had contact. There are many other centres of astronomical activity, from the Baltic to the Far East, which I have not seen.

Moscow: The P. K. Sternberg Astronomical Institute (Director: D. J. Martynov) is the main centre of astronomical work in Moscow; it forms part of Moscow State University. It has a number of good instruments of fairly modest dimensions, such as can profitably be used within the precincts of a great city; it has an out-station in the Crimea for work that cannot be done under the conditions in Moscow. But in spite of the limitations upon its observational work, it is exceedingly active in a wide range of research and development, including, for example, the provision of a time-service, work on laboratory spectra, the production of various important catalogues (variable stars, galaxies), and some very significant theoretical investigations.

Other groups in Moscow also do work of astronomical interest. The

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O. Schmidt Institute of Earth Science is administered directly by the Academy; it contains a small but vigorous group working on various problems of cosmogony, some of these arising from the theories of the late Academician O. Schmidt. There is also, for example, a group at the University interested in problems of relativistic cosmology; they have tackled some difficult mathematical problems of the subject.

Leningrad: The Pulkovo Observatory (Director: A. A. Mikhailov) already mentioned is still the leading observatory in the USSR in fundamental astronomy and the determination of astronomical constants. In fact, much of all current work in this field is shared between the Pulkovo Observatory, the Royal Greenwich Observatory, the Paris Observatory, and the United States Naval Observatory, Washington, in the northern hemisphere, and the Cape Observatory in the southern hemisphere. But Pulkovo is active in a wide range of other fields too. Various telescopes of novel design have been invented and developed there, notably the Maksutov meniscus telescope, which achieves the advantages of a telescope of long focal length without the need for a correspondingly long tube. Pioneering work is being done in 'laboratory astrophysics': for instance, I was shown an underground tube 100 metres long from which the air can be evacuated and other gases can be introduced at pressures from 20 atmospheres to one-twentieth atmosphere; then by sending light back and forth several times through the length of this tube it is possible to study the formation of spectral lines under conditions somewhat like those in a stellar atmosphere. Pulkovo astronomers have also developed a novel version of one form of radio telescope. It consists of an array of 90 separate plates that add up to make a strip of a paraboloid of great aperture; suitable separate motions of the plates is equivalent to turning the axis of the paraboloid in declination; the effect is to produce, at a relatively negligible cost, an instrument roughly like the great Jodrell Bank radio telescope, though not one of quite comparable precision.

In Leningrad, too, there are other institutes with astronomical interests, including the Institute of Theoretical Astronomy which appears to be concerned principally with celestial mechanics.

Crimea: The Crimean Astrophysical Observatory (Director: A. B. Severny) is an institute of the USSR Academy of Sciences. It has a fine site on a plateau nearly 2,000 feet high, in the central part of the Southern Crimea. It is a part of the world that has seen a succession of more cultures than possibly any other. And now the observatory forms a new community of several hundred souls within sight of ancient cave dwellings. Construction began in 1946 and now, besides the domes, aerials, and observatory offices, there is a fine hotel for the reception of visiting scientists and for accommodating some unmarried staff, an imposing row of houses providing flats for senior scientific staff and their families, many small houses for the artisans who work on the site and who are allowed to make use of any vacant plots to keep

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poultry and other animals, and a large primary school for young children belonging to the community and others from the surrounding countryside. On several nights in the week there are film shows; the films come from all countries but are dubbed in Russian. A feature that may be unique in observatory life is that in the middle of every morning a young member of the staff goes round the offices to muster volunteers for a 10-15 minute PT-class, which is carried on the Moscow radio.

The work of the observatory is in several main departments. One is in stellar astronomy, and is now dominated by the 120-inch telescope completed in 1960. Very fine work on solar physics is done in the solar department, which has one of the best solar tower telescopes in existence. There are also solar radio-telescopes. Another department studies solar-terrestrial relations through ionospheric and magnetic phenomena.

The older Crimean observatory is now organised as an out-station of the main observatory. It is at Simeiz on a magnificent site overlooking the Black Sea. On the shore below is a new radio telescope designed for work at very short wavelengths. In the Crimea, too, is the fabulous deep-space tracking station, to which Sir Bernard Lovell was recently the first foreign visitor.

WE HAVE BEEN DISCUSSING INSTITUTIONS associated with the capital of the USSR either through its Academy or its University. We come now to mention institutions in two other republics of the Union, those of Georgia and Armenia. The spirit of the scientific work being done there can scarcely be understood without recalling that the Georgians and Armenians, although so different from each other, are both proud and ancient peoples with age-old traditions in religion, art, and learning. But, through many centuries, they have known little but pillage and oppression coming from all sides. For some forty years now, even in spite of the second World War, they have had security that they have never known before. The result has been an upsurge of local culture of all sorts, coupled with an ardent desire to play their part in the great advances of our age. While the astronomers may not consciously think much along these lines, I believe that to some extent all the scientists in these countries are carried on the crest of the wave of renaissance of their peoples.

Georgia: The Abatstumani Astrophysical Observatory (Director: E. K. Kharadze) is at a height of over 5,500 feet in the Caucasus, on a site that was temporarily occupied for astronomical work around 1890. The present observatory was established in 1932; it is still one of the very few mountain observatories in Europe. The work, for which its good observing conditions specially fit it, has mostly to do with systematic astrophysical observations, many being designed to elucidate the structure of the Galaxy.

The Observatory is closely linked with the Department of

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Astronomy in the Tbilisi State University, where theoretical studies connected with its work are carried out. At present, however, the chief link with the University is the remarkably gifted Director. He is also Rector of the University, over which he presides with dignity and charm. It is in one of the most fascinating cities in the world, where one feels oneself to be at the meeting point in space and time of all the cultures of the East and West.

Armenia: The Byurakan Astrophysical Observatory (Director: Academician V. A. Ambartsumian) is at a height of nearly 5,000 feet on the slopes of Mt. Agarat with a commanding view to the south where the magnificent peak of Mt. Ararat dominates the scene. The observatory buildings are constructed in Armenian style from a warm-coloured variety of the local felsite. There are many trees, shrubs, and flowers amongst the buildings, so that the whole establishment has an atmosphere of geniality, entirely in keeping with the spirit of the people who work there.

The observatory grew out of the Department of Astronomy of Erevan State University; the first telescope was installed at Byurakan in 1946, and by 1956, when the official inauguration took place, it had a great variety of instruments for astrophysical studies. More recently, it has acquired its most notable instrument, a Schmidt telescope that is second in size only to the Palomar 42-inch Schmidt. Somewhat higher up the mountain at Saravand, there is a large observatory for radio astronomy, also with a variety of instruments of which the largest is an interferometer similar to the first big Cambridge instrument.

Two things that are not easy to find on the mountain-side are level ground and grass. However, the astronomers have found a somewhat rough and rocky playing field and there the optical and radio workers engage in desperately-fought soccer matches. This activity may be traceable in some way to their proficiency in English; a gifted instructor spends two days a week taking them in small groups for English conversation.

Achievements and Prospects

IN THE PAST FIFTEEN YEARS OR SO, great effort has gone into the building of instruments and in training people to use them. The USSR has now about as many astronomers as the USA. I gain the impression that the era of providing basic equipment is over for the time being and that the astronomers are poised for massive attacks on some of the great problems of our times. On the instrumental side, it seems likely that Soviet astronomers will concentrate upon the invention and development of more novel instruments. They have plans for erecting giant radio and optical telescopes high in the Caucasus; just because they are to be bigger than anything attempted before, they are bound to possess novel features.

In almost every branch of astronomy, observational and theoretical,

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Soviet astronomers have made important contributions in recent years. It is hard to single out any without the risk of failing to mention something of more significance. To attempt to pick on one or two characteristic contributions, we might first recall that Ambartsumian and his school have done much observational and theoretical work to call attention to stellar associations and to the problem of apparently dispersing stellar systems within the Galaxy. Their ideas have come to play an important part in current thinking on stellar and galactic evolution. They are now developing somewhat analogous notions regarding whole galaxies (including the so-called star-galaxies) and systems of galaxies. Severny and his school have opened up new fields of study of details of velocity-fields and magnetic fields on the Sun, particularly in sunspot regions. Soviet astronomers have also devoted special attention to the astronomy of interstellar space; the names of G. G. Getmantsev, V. L. Ginzburg, S. B. Pikelner, and I. S. Shklovsky are associated with a major contribution to the development of current ideas on the production of radio emission by 'relativistic electrons' moving in magnetic fields in the Galaxy and its 'halo'.

Soviet astronomers are well acquainted with the world literature of their science. In recent times, Soviet writers have produced notable textbooks and monographs on mathematics, physics, and astronomy, many of which are in daily use in English translations. Naturally, they also produce a large volume of original papers in their own scientific journals.

I END ON THE NOTE on which I also began—that of international cooperation. We can welcome all the developments that I have had to record because, if astronomers are true to their own traditions, the results got inside and outside the USSR will be shared to the enlightenment of us all.

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Russian Plans for Space

Sir Bernard Lovell, F.R.S. in conversation with John Maddox

SIR BERNARD, who is professor of radio-astronomy at Manchester University and director of the Radio-astronomical Observatory at Jodrell Bank, was a guest of the Soviet Academy of Sciences in June and July 1963, when the international competition to reach the Moon had been given additional public interest by the apparently effortless journeys of both American and Russian astronauts. In the United States especially, the summer of 1963 was one in which people were most anxious about the outcome of what was thought of as the race to the Moon. Who was likely to win? And in any case, was the race worth running? Americans were divided into those who thought that more money should be spent on the programme of space flight by human pilots, and those who thought that these activities did not justify the vast sums being devoted to them. As it happened, members of both groups were disconcerted when Sir Bernard Lovell returned from Moscow with the announcement that, in his opinion, there was no race at all. The Russians, he said, were not concerned to reach the Moon this decade, or by any other predetermined date. They would go when it seemed to them convenient to do so. It was inevitable that the matter should be raised in public with President Kennedy.

But if the Russians are not racing to the Moon, they are without question supporting a vast programme of exploration by earth satellite, and by rockets which reach still further out towards the edges of the Solar System. So much has been clear since the first sputnik was launched in 1957. It tends less frequently to be remembered that the more spectacular aspects of the Russian interest in space have grown out of scientific preoccupations of a much more conventional character, and which are shared with smaller countries such as the United Kingdom. What follows is a summary of Sir Bernard Lovell's impressions of Russian work in radio-astronomy and related fields of science, gleaned from him during an informal conversation early in 1964, six months after his return from the Soviet Union.

In radio-astronomy, as in the classical branches of astronomy, progress depends on instruments. An observatory is no better than its radio-telescopes. At Jodrell Bank, for example, the great parabolic aerial, shaped like a gigantic searchlight 250 feet across, is the corner-stone of the attempts which are being made to detect radio emissions from galaxies lying towards the edges of the Universe. Physical size brings precision and sensitivity. Though they appear to have started late, the Russians are now building instruments capable of harvesting a wealth of information about the radio waves from distant stars and galaxies of stars.

The first instruments for radio-astronomy were built in the Crimea. There was, for example, a hollow bowl 200 feet in diameter scooped

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out of the surface of the earth, and constructed with such precision that it could detect radio waves whose wavelength is a mere 21 centimetres—that corresponding to the radio emissions of hydrogen gas to be found dispersed among the spiral arms of the galaxy which includes the Solar System. It is notable that a large instrument of this kind has just come into service in Puerto Rico under the auspices of the National Science Foundation in the United States. One of the first instruments at Jodrell Bank was also a fixed bowl-like structure pointing upwards to the sky, but that one was built of wire cables and wire netting strung between poles mounted in the ground.

As it happened, the Crimean instrument did not survive the passage of a few years, and the movements of rock which are a fairly common occurrence in those volcanic parts, and which distort the operation of radio-telescopes. The observatory was for this reason moved to Serpenov, 90 kilometres from Moscow, and equipped with instruments for radio-astronomy more flexible than mere depressions in the surface of the earth. Sir Bernard Lovell, himself provided with some of the best instruments of this kind, is full of admiration for the way in which the Serpenov observatory has been fitted out. The first radio-telescope to be built there was shaped like a searchlight which could be pointed to any part of the sky, but whose diameter was no less than 22 metres. Russian skill in the design of heavy artillery is likely to have helped with the solution of the great mechanical problems of making such a large structure at once so manoeuvrable yet so rigid that it was capable of the accurate observations of radio waves with high frequency (or short wavelength) for which the Russians have become renowned. The parabolic surface of the 22 metre telescope is made up of no fewer than 270 aluminium plates, and these can be adjusted separately so as to tune the aerial for its job in much the same way that the reverberation and the other acoustic properties of a modern concert hall can be determined by the adjustment of movable resonating surfaces in the walls.

But one such telescope is not the end of the story. At Serpenov the Russians have created a complex of eight of these instruments which work together on the tracking of distant sources of radio-emission in the universe. Though the combination of more than one radio-telescope into a complex of instruments is now a standard way of increasing the precision of certain measurements, it is clear that the Russian complex of eight 22 metre telescopes is a considerable technical *tour de force*. This will soon be matched in character, however, by the large array of telescopes spread out over a kilometre at the Serpenov site.

RADIO-ASTRONOMY is now also the more or less exclusive concern of the observatory at Pulkovo, near Leningrad. This was the establishment which won a high reputation in the first half of the century for its conventional optical astronomy, which was destroyed during the siege of the city during the second world war, and which has now been restored in its original form. The observatory is still occupied

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with the improvement of instruments for the recording of measurements with optical telescopes, but interest in the classical parts of astronomy has shifted elsewhere. Pulkovo, however, is equipped with a unique instrument for detecting radio waves from distant parts of the universe—one made up of an array of ninety tilting plates. This same principle may be embodied in the design of a gigantic instrument being considered for the Caucasus. There is a scheme to use a combination of 550 plates, each measuring 15 by 6 metres, as a radio-telescope stretching over two kilometres, and able to work in conjunction with an optical telescope —236 inches in diameter—considerably larger than the largest optical telescope in the United States.

The existence of classical and radio astronomy cheek by jowl in this fashion is by no means unusual in the Soviet Union, though Sir Bernard is not sure that the virtues of the arrangement have yet been demonstrated. The Astrophysical Observatory in the Crimea, which has had a longstanding interest in the properties of the Sun (a special study of sunspots, for example, has been conducted there), has naturally extended its interests to include the measurement of radio emissions from the Sun. The observatory at Burakan has also taken up radio-astronomical work. Neither of these dual purpose observatories is comparable, either in scale or in quality, with the centres at Serpenov and at Pulkovo.

Of all installations of this kind, however, Sir Bernard was most impressed by the deep space tracking station in the Crimea—an institution separate from the Astrophysical Observatory, whose chief purpose is to assist with the tracking of Russian space rockets, but whose capacities have already won valuable information on questions such as the distances from Venus to the earth—a quantity which bears in a significant way on the problem of trying to establish accurate dimensions for the Solar System, and by extension the universe itself. This station cost between £15 and £20 millions in the year 1959–60, which implies that the scale of Russian spending at this one station is perhaps ten times as great as that in the whole of the United Kingdom. Sir Bernard's impression is that canny radio-astronomers have recognised the Russian space programme to be a valuable means of endowing themselves with excellent equipment. The thing that impressed him most at the space tracking station in the Crimea was the way in which the Russians were able to transmit narrow beams of radio waves with such great intensity that they could reach out to the planets Venus, Mars, Jupiter and Mercury, and in exactly the way in which a radar beam will pick out an aircraft in the sky. Because of the power of its radio-transmitters, and the quality of its radio-telescopes, the Crimean station is the only one so far to have been able to bounce radio waves off the surface of the planet Jupiter.

If Russians are satisfied with the usefulness of their space tracking station, it would appear that they are less certain about the objectives of their space programme proper. On the whole, Sir Bernard's impression was that a large majority of the members of the Academy of Sciences would be satisfied with the landing of instruments on the surface of

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From an Astronomer's Diary

MY FIRST SUPERFICIAL IMPRESSION of the different institutes of the Academy of Sciences was that they did not essentially differ from similar institutes in Germany. Many of the institute buildings are, by American or post-war German boom standards, fairly out of date, but despite their aged exterior, these institutes have better resources than the older physics institutes of the universities in the Federal Republic. My general impression of the apparatus and equipment was also very favourable.

Most of the institutes I visited are attached to the Academy of Sciences; the others are university institutes. The first on the programme was the Institute for Physical Problems (Vavilov Institute), which has as its director P. L. Kapitsa, who spent a considerable time in England and who directs experiments in liquid helium. I saw the famous—by now historical—apparatus which was originally built in England. In addition to the deep temperature experiments in helium, physics of solid bodies enjoys special significance in this institute. Among the members of the institute are Nobel Prize winners Landau and Lifschitz, the authors of the most comprehensive and modern text-book on theoretical physics now available; it has won great acclaim in the West.

In every institute we had exhaustive discussions about current scientific problems. Besides conversations with internationally famous members of the institutes, we also met a number of young scientists who stressed their keen interest in contact with visitors from abroad. During my stay in Moscow a meeting of young astronomers took place. I was invited to the final session and asked to give a short address; the attendance at this meeting was remarkable—over a hundred young astronomers who have just finished or are about to finish their training.

With regard to physics, the visit to the Kurchatov Institute for Atomic Energy was particularly impressive. This institute occupies a large area in a Moscow suburb, and has a staff of several thousand. It consists of a number of departmental institutes, and I had an opportunity of seeing some of the work being done there in the field of plasma physics. I was greatly impressed by the scale of the experiments and the expensive instruments, particularly as I know institutes with similar working equipment in Europe as well as in the United States. The efforts being made in this field—and this is not the only place devoted to it in the USSR—are really extraordinary. The work there has been under way for at least ten years, and all the experimental equipment is highly developed. A number of different methods have in the meantime been proposed for including and maintaining plasma which has been strongly heated through magnetic fields in a pre-calculated volume. A whole series of such large scale parallel experiments has been carried out. With so-called *Spiegelmaschinen* (often termed magnetic bottles) they have been able to achieve relatively long periods of inclusion (of tenths of a second). Among other things I was shown the largest *Spiegelmaschine* in existence, called OGRA, the plans for which attracted considerable attention in 1958 at the Geneva Conference on the peaceful uses of atomic energy.

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the Moon; the need to send a man does not command universal assent among Russian scientists. He gathered that there was no precise programme for the landing of a man on the Moon, and a great deal of concern about the risks to the Moon travellers of radiation from the Sun. It is now recognised that visible disturbances on the surface of the Sun are usually accompanied by the ejection of streams of fast-moving atomic particles which could expose space travellers to dangerous doses of radiation.

AGAINST this background, Russian plans for space are at once more pragmatic and more ambitious than the American. Their immediate objective in human space flight is to establish a space platform whose crew could be recovered fairly quickly in the event of storms of radiation from the Sun, and whose existence outside the atmosphere of the earth would be an invaluable means of carrying out a great deal of important scientific observation. This will be an expensive project even by the standards of the American Project Apollo—the name given to the United States Moon programme. In the Soviet Union, as in the United States, there appears to be a continuing argument about the potential military usefulness of space travel. Nobody has yet uncovered a way in which space techniques might serve a decisive military end, but this does not suffice to put an end to speculation. On the whole, Sir Bernard is persuaded that in making decisions about the spending of money on space research and space travel, the Russians are more rational and more single-minded that the Americans.

At the same time, the Americans appear to be capable of greater technical sophistication. The failure of the Russian rockets sent towards Venus and Mars is one illustration of American superiority in the design of rocket instruments. But the Russian rocket that took pictures of the back of the Mooon—Lunik II as it was called—was a great spectacle and a great success. This direct approach to space research is typical, Sir Bernard Lovell believes, of the Russian attitude towards space research.

And what of the future? He was impressed by the deep Russian interest in the exploration of the planets of the Solar System. So he thinks that the bias in the Russian space programme in the next few years will be one that is intended to uncover more information about the planets. He thinks there will be a great effort to develop rockets accurate enough and powerful enough to carry out these remote and automatic journeys of exploration to places which are not likely to be visited by human beings before the end of the present century. Why are the Russians so concerned? Sir Bernard says that they were surprised to see how great an impact the first sputnik made, but that since then it is understandable that they should have turned their rocketry to propagandist use. But now, he thinks, there has been a change. The Russians do have a real and almost tangible wish to find out what the rest of the Solar System is like. In space research, they are not primarily propagandists.

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CHEMISTRY
Towards Bolshaya Khimiya

John Turkevich

CHEMISTRY occupies a key position in twentieth-century civilisation. Situated between physics and biology, it affects them more than they affect it. The great technological developments due to physics—atomic energy, intercontinental missiles, space travel, electronics—all have required special materials that chemistry had to furnish. The striking advances of biophysics, genetics, public health, and medicine are predicated on the development of knowledge of complicated molecular structures and of multiple interacting chemical systems. If we examine carefully the diverse technological processes that underlie the modern economy—agriculture, ferrous and non-ferrous metallurgy, textile and plastics industry, communication and transportation complexes—we will find that they too are based on chemistry.

Chemistry is thus a basic science. It is a science that must be highly developed in a country if that country is to be a great modern industrial state. Large numbers of well-trained chemists are necessary for satisfying modern living. Many of the troubles that face the Soviet Union—difficulties in feeding and clothing the population, and inadequate housing—can be traced to the insufficiency of chemists with enough laboratories and reagents to discover, develop, and manufacture the necessary chemicals. This weakness is due to lack of adequately trained manpower, lack of intelligent leadership, lack of research laboratories. It is due to inadequate investment in chemical research and insufficient knowledge of Western chemical engineering and technology. Soviet chemical laboratories turn out voluminous research papers but most of them are pedestrian in character. Soviet scientists have made significant contributions to various branches of academic chemistry, yet their engineering colleagues have not been able to translate them into chemical plants. Compared to Soviet physics and mathematics and contrasted with the chemistry of the West, Soviet chemistry is very weak.

A proper assessment of a science in a given country requires knowledge of its historical background, its organisation, the material basis of its laboratories and equipment, the availability of imaginative and strong leadership, and the training of a broad base of professional and skilled manpower. Here we come up against the usual problems for the Western scholar: the reluctance of the Soviet science administration and Soviet scientists either to talk about the situation in the Soviet Union or to permit foreigners to make extensive visits to their laboratories. The present discussion is thus handicapped from the outset.

Chemistry in the Soviet Union has a long and distinguished past. The

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skills of the Russian monks and craftsmen of the Middle Ages laid the empirical foundation for science in Muscovy, as they did in Western Europe. With the founding of the Russian Empire by Peter the Great in the early eighteenth century, Western scholars emigrated to the court of St. Petersburg and Russian students studied in the West. Through their efforts the scattered bits of knowledge acquired through the ages in Russia became incorporated on an international basis, and chemistry became a science. M. V. Lomonosov (1711–65), the encyclopaedic stormy genius of Russian science, established the first chemical laboratory in the Academy of Sciences at St. Petersburg. The eighteenth century was an induction period for international chemistry as key problems were formulated from the mass of organised empirical observation. It was also the time when Western learning, culture, and tradition gradually penetrated through the upper classes into the middle classes of Russian society. This penetration was facilitated by the establishment in the eighteenth and the beginning of the nineteenth century of the universities of Moscow, St. Petersburg, Kazan, Kiev, and Odessa. Chemistry expanded from the Imperial Academy and the State Apothecary Establishment at St. Petersburg across Russia. While Russian chemists had only a peripheral influence on the solution of the key problems of combustion, respiration, and calcination, their role was central in the development of world chemistry during the nineteenth century. Modern inorganic, organic, analytical, and physical chemistry would show serious gaps if the contributions of Russian chemists had not been made. Mendeleev (1834–1907) formulated the periodic table of chemical elements, Klaus (1796–1864) discovered the element ruthenium, while others developed a variety of organic syntheses and helped to systematise the structure of organic chemistry. Beilstein (1838–1906), a professor at the St. Petersburg Technological Institute, compiled the first systematic bibliography of organic compounds, and later editions of the work still bear his name, though it is now compiled by a large organisation. Ipatiev (1867–1952) pioneered in high pressure chemical reactions and was for decades foremost in the field of catalysis. Hess (1802–50) discovered important laws of thermochemistry that bear his name, while Menshutkin (1842–1907) laid the foundation of reaction velocity studies in organic chemistry, and Walden (1863–1957) during the first half of his scientific life developed in Russia his work on non-aqueous systems and discovered the Walden inversion. Chugaev's (1873–1922) application of organic reagents for the analysis of metals and his discovery of the dimethyl glyoxime test for nickel are known to millions of students of chemistry throughout the world. These and many other names and contributions are known to all students of chemistry. They represent outstanding scientific achievements and their influence can be discerned many decades later in Soviet chemistry.

THE revolution of 1917 and the civil war that followed naturally hampered the development of chemistry in Russia. Some eminent

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chemists, such as Ipatiev and Chichibabin, left for the West, part of the emigration which included many prominent leaders of Russian intellectual and artistic life, and hundreds of thousands of the Russian middle classes who were the source of the Russian intelligentsia. Those who remained to survive the humiliations, frustrations, and privations of the early years of the communist regime gradually came back into their own with the introduction of the five-year plans. These emphasised the need for professionally trained people, and many new universities were established. Basic chemical industry was developed. The momentum of the chemistry of Imperial Russia carried Soviet chemistry through the period between the two world wars, the leaders of the pre-revolutionary period still dominating the Soviet chemical scene. Their students and successors came from the same class—the old Russian intelligentsia.

During this period work on inorganic chemistry was carried out in a number of newly established institutes. At the Institute of General and Inorganic Chemistry Kurnakov and his students continued the work on phase diagrams, laying the foundations for Soviet metallurgy, and Chugaev and his successors studied formation of complexes by metals with organic compounds and found widespread applications of these materials in analysis and metal extraction. At the Karpov Institute of Physical Chemistry in Moscow, Kazarnovski (1890–) worked on simple inorganic compounds such as the peroxides and superoxides of the alkali metals. The work of Ipatiev was continued at the Leningrad Institute of High Pressures. The importance of chemistry in agriculture was recognised with the establishment of the Scientific Research Institute of Fertilisers, Agrotechnology, and Agricultural Science, and with the organisation of the Samoylov Scientific Research Institute of Fertilisers and Insectofungicides.

During this same period an important school of electrochemistry was developed under the leadership of A. N. Frumkin (1895–); their work in electrochemistry has been held in high regard throughout the world for several decades. Radiochemistry was initiated in the Soviet Union during the civil war, when methods were perfected for the extraction of radium from the Central Asian deposits. The Soviet radiochemists trained at the Radium Institute, founded in 1922, helped immeasurably with the Soviet atomic energy programme, although their contributions to the radiochemistry of the period since the war are not so significant as those of the Frumkin school of electrochemistry.

Physical chemistry has always been a particularly strong field in the Soviet Union. Work on absorption and emission spectra of molecules and their relation to chemical transformations was carried out by Kondratiev (1902–) at the Institute of Chemical Physics in Moscow, and by Terenin (1896–) at Leningrad University. Other leading scientists have done excellent work on the sorption of gases on solids and in the field of catalysis.

An outstanding group of chemists was organised and trained in the

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Institute of Chemical Physics. Their work, carried out under the directorship of Semenov, laid the foundations of our knowledge of elementary chemical reactions, chain reactions, and explosions. The theory of chain explosions, so important for the understanding of the mechanism of detonation in internal combustion engines and for the behaviour of neutrons in nuclear fission, was formulated by Semenov, who received the Nobel Prize in chemistry in 1956.

Organic chemistry during the period between the two wars was centred on hydrocarbon transformations, organo-metallic compounds, and organo-phosphorus chemistry. Zelinski and his students investigated the interconversion of various hydrocarbon classes; Favorski and his school concentrated on the chemistry of acetylene derivatives, while Lebedev worked out a synthesis of rubber from ethyl alcohol. Professor Nesmeyanov was the leader of the Soviet group working on the organic compounds of mercury, arsenic, lead, gold, zinc, cadmium, bismuth, and many other metals. The publications of his school dominated the world scientific literature on this subject. His findings have found application in anti-knock compounds for internal combustion engines, in insecticides and fungicides for agriculture. At the same time they represent a structure of knowledge worked out in detail by one man. The organic chemistry of phosphorus compounds was and still is the speciality of the Kazan University chemists under the direction of Professor Arbuzov. Work in the organic chemistry of natural products and medicinals was not developed in the Soviet Union as extensively as in the West.

The second world war, the devastation caused by enemy occupation, and the isolation of Soviet intellectual life under Stalin, again raised havoc with Soviet chemistry. The chemistry of the years since the war is not so strong as it was before. The scene today, however, still shows strong traces of the schools of Vernadski, Frumkin, Semenov, Arbuzov, and Zelinski.

CHEMICAL research and investigations in the USSR are carried out under the auspices of the Academies of Sciences, All-Union and Republican, and under the control of the Ministry of Higher Education at the various universities and advanced technological schools, under the administrative control of various ministries, the State Committee of the Council of Ministers on the Coordination of Scientific Research, the State Committee on Chemistry, at the State Committee on Peaceful Uses of Atomic Energy, and undoubtedly at secret military installations. Information about the research work carried out at the institutes of the academies and the laboratories of the universities is extensive, but there is only scanty information on the work carried out at the numerous chemical laboratories of the various ministries, both military and civilian. Nor do we have data on just how far the State Committee on the Coordination of Scientific Research has been successful in coordinating activities as diverse as those of chemistry.

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The Academy of Sciences of the USSR is the supreme scientific authority in the Soviet Union. During the last two decades its leadership has been dominated by organic chemists. A. N. Nesmeyanov was president of the academy from 1951 to 1962, and the late A. V. Topchiev (1907–62) was the political power in the academy, being successively academician-secretary and vice-president in charge of foreign relations.

Since its last reorganisation in the early summer of 1963 the Academy consists of three main sections: the physico-technical and mathematical sciences, chemical, technical and biological sciences, and social sciences. Chemistry thus falls into the second section; the head of this section is a chemist, N. N. Semenov; three of its five divisions deal directly with chemistry: the division of general and technical chemistry, under academician Nesmeyanov, the division of physico-chemistry and technology of inorganic materials, under academician Zhavoronkov, and the division of biochemistry, biophysics, and chemistry of physiologically active compounds, under academician M. M. Shemyagin; the academician-secretary is a biochemist. Here we can attempt no more than a brief description of the work of scientific research institutes and laboratories in which chemistry is the main subject of investigation, dealing first with the institutes of the USSR Academy of Sciences, which overshadow those of the Academies of the Associated Republics and of most universities, except that of Moscow.

The Kurnakov Institute of General and Inorganic Chemistry in Moscow is concerned with phase studies, the chemistry of complex compounds, the extraction of rare elements, and the preparation of unusual inorganic compounds. Theoretical work and quantum chemistry has been revived at this institute after a decade of party disfavour. Its director is academician N. M. Zhavoronkov.

The Institute of the Chemistry of Silicates in Leningrad deals with the synthesis and study of silicate systems. Work is carried out on the synthesis of synthetic zeolites. Its director is academician N. A. Toporov.

The Vernadski Institute of Geochemistry and Analytical Chemistry in Moscow carries out research in geochemistry, radiochemistry of bombardment products of high-energy accelerators and nuclear reactors, studies the composition of meteorites, and develops analytical methods. The director is academician A. P. Vinogradov.

The Zelinski Institute of Organic Chemistry in Moscow is the main institute for organic chemistry in the Soviet Union, and has imposing premises. Work is concentrated on hydrocarbon chemistry, the synthesis of petrochemicals from simple unsaturated compounds, and the chemistry of nitrogen and sulphur heterocyclic compounds. A good deal of work is also done in the heterogeneous catalysis of organic compounds. The director of the institute is academician B. A. Kazanski.

The Institute of Elemental-Organic Compounds was built recently for academician A. N. Nesmeyanov and is under his direction. The

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main line of investigation follows his special interest—compounds of metals with an organic moiety.

The Institute of the Chemistry of Natural Compounds has been organised recently and housed in a new building to bolster up research in compounds that are synthesised in biological systems or have biological significance. Its director is academician M. M. Shemyakin.

The Topchiev Institute of Petrochemical Synthesis in Moscow was established in 1959 to study the utilisation of petroleum and natural gas for the production of chemicals, especially for the plastics industry. Its principal scientists are V. A. Kargin, the Soviet leader in polymer research, and corresponding Academy members Bashkirov and Lavrovski.

The Institute of High Molecular Weight Compounds in Leningrad deals with the synthesis of polymers and the study of their physical and mechanical properties. The director is corresponding Academy member Koton.

The Institute of Chemical Physics is under the direction of academician N. N. Semenov, Nobel Laureate in Chemistry. Here investigations are carried out both on the theoretical and experimental aspects of the chain reactions, particularly those associated with flames and explosions. Important scientists on its staff include academician Kondratiev, the associate director, who works on elementary reactions; corresponding member N. M. Emanuel, who has worked on liquid and gas phase oxidations of organic compounds and is now working on free radical inhibition in biological processes; G. A. Razuvaev, who is investigating the peroxide oxidation of naphthalene derivatives; S. Z. Roginski, studying the mechanism of heterogeneous catalysis; V. V. Voevodski, who is applying electron paramagnetic resonance techniques to a variety of physico-chemical systems; K. I. Shelkin, investigating the mechanism of detonation; K. K. Andreev, working on the combustion of liquid explosives; and V. L. Talrose, who has measured the kinetics of electron transfer between molecules by means of the mass spectrometer.

The staff of the Institute of Physical Chemistry in Moscow are concerned mainly with the effects of radiation on physical and chemical properties of compounds and the study of heteropoly and isopoly acids; surfactant mechanisms; adsorption phenomena; surface phenomena and forces; metal corrosion.

The Institute of Electrochemistry in Moscow is under the direction of academician A. N. Frumkin. Work is carried out on electrode processes, electrochemistry, radiation effects, and fuel cells.

The Khlopin Radium Institute in Leningrad has been the centre of radiochemical research and nuclear studies for the last forty years. Its director is the corresponding member V. M. Vdovenko.

The Bakh Institute of Biochemistry in Moscow is concerned with various aspects of biochemistry. Its director, academician Oparin, is concerned with the problem of origin of life; other academicians working there are doing research into animal biochemistry, enzymology, and photochemistry.

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The Karpov Physico-Chemical Institute in Moscow carries out important research in the most varied fields of physical chemistry, catalysis, polymer chemistry, radiation chemistry and metallurgy. It is under the Ministry of Chemical Industry and is directed by K. A. Kocheshko.

RESEARCH is also carried out at Soviet universities but to a much smaller extent than at the institutes. In fact, Soviet science administrators have repeatedly pointed out that university research as carried out in the West has been the source of the major discoveries in science. Research in chemistry is most prominent in the universities of Moscow, Leningrad, and Kiev. The Lomonosov University of Moscow carries out chemical investigations in two separate buildings in the large university complex on Lenin Hills. The research topics in inorganic chemistry are hydrogen peroxide, ozone, polycarbonates, carbon black, metallic alloys, semiconductor materials, rare earths and ferrites. In organic chemistry work is carried out on petrochemicals, polymers, organic sulphur compounds, and mechanisms of organic reactions. In physical chemistry work is concentrated on the structure of solutions, electrolytes, catalysis, adsorption and radiation effects.

The Zhdanov Leningrad University is the second largest university in the Soviet Union. Research is carried out into alkali metals, rare earth metals, uranyl compounds, glass, metal organic compounds, polymer chemistry, phase studies, ion exchange resins, surface phenomena, and radiation chemistry.

At the Shevchenko University in Kiev, the third largest in the Soviet Union and the centre of scientific work in the Ukraine, research in organic chemistry is concentrated on high polymer work though there is considerable work in dye chemistry. Work in inorganic chemistry is carried out on preparation of metals in ultrapure state, rare earth chemistry, and physical metallurgy.

All the above research establishments have been visited at one time or another by foreign scientists; a few have been examined in detail, while in other cases the visit has been limited to the director's office. There are many other important centres of chemical research that have not been seen by foreign chemists. One of these is the Institute of Organic Chemistry at the University of Kazan, and another is the complex of chemical institutes of the Siberian department of the USSR Academy of Sciences at Novosibirsk. The Siberian department was organised in 1957 as a centre of science for the vast territory of Siberia, and a number of prominent scientists left Moscow to become members of the newly organised science institutes. They were elected to membership in the USSR Academy of Sciences as an inducement to go to Siberia. The active chemical institutes in Novosibirsk are those of catalysis, chemical kinetics and combustion, geochemistry, inorganic chemistry, and organic chemistry. Except for a conference on applied

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mathematics held in the fall of 1963, this science city has been closed to foreign scientists.

A survey of chemistry in the Soviet Union would be incomplete without some attempt at evaluation, and if no comparison were made with Western chemistry. Evaluations are of course difficult to make in any country, and this is particularly true in the Soviet Union where travel is restricted, visits to most laboratories impossible, and contacts and discussions with Soviet scientists perfunctory. On the basis of the voluminous Soviet chemical publications and of the limited chemical research institutes that we have been shown, we must conclude that Soviet chemistry is weak and has become weaker since the Second World War. It is weak not because it does not have brilliant chemists—these it has. It is weak not because the young are not interested in science—they are. Soviet chemistry is weak because the present isolation of Soviet intellectual life from the West does not permit the young and professional chemist to have contact with the chemistry of the West, but limits these contacts to a few science administrators; because the number of chemical research laboratories is small compared to what is necessary for a modern economy and small compared to the number in the United States; because these laboratories are for the most part crowded, old and unsuited for modern chemistry; because modern instrumentation, laboratory services and supply of chemical reagents are deficient except in a few prestige laboratories, and the laboratories are clogged with a plethora of junior workers, most of them women, who do pedestrian research, with no chance of moving up the scientific ladder.

It is to be hoped that the years ahead will permit a freer flow of information and closer scientific contacts with our Soviet colleagues. We shall then see the strong points of their science and culture which we now find difficult to discern, and share with them the scientific affluence of the age.

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LYSENKO'S MAIZE

David Joravsky

WHAT has made Soviet biology different from standard world biology? The obvious answer, endlessly repeated, has been: Marxist-Leninist ideology. But this answer is patently inadequate. Marxist-Leninist ideologists have exerted themselves to transform physics much more strenuously, over a much longer period, yet Soviet physics has seen nothing comparable to the Lysenko movement. What is more, most of the people who started Lysenko's movement about thirty years ago were not professional ideologists but agronomists, plant breeders, agricultural officials. This would seem to confirm the endlessly repeated claim of the Lysenkoites that their school was created by and for the practical men of Soviet agriculture. But how can that be? Do not crops grow and reproduce the same way the world round? And if so, if nature is uniform, must not men's use of plants and their scientific understanding of them follow a worldwide pattern of development? Let us call these questions, as the Marxist-Leninists do, questions about theory and practice, biological theory and agricultural practice, and let us seek answers in Lysenko's maize.

Maize crossbreeds promiscuously. All the tassels thrust up from a field of corn drop pollen for all the silks below; the intervening wind indiscriminately fertilises all the sticky female parts with the dusty sperm dropped by all the male parts. In this sense 'hybrid corn' is as much a tautology as wet water; maize naturally and continuously hybridises, crossbreeds, as far as the wind carries its pollen. An enormous variety of crosses results, and from them the natural environment and the farmer select those that survive and serve human needs best. The early American Indian bent the selective process so strongly towards human needs and away from natural conditions that maize became a purely domesticated plant, entirely dependent on human cultivation for survival. If we assume that the Indian's thought processes were superstitious rather than scientific, then we must grant that there is no necessary, one-to-one correlation between practical success in the manipulation of nature and theoretical truth in the accompanying explanations.

Let us leap centuries ahead of the ancient Indian. Inbred hybrids of maize are the greatest practical achievement of 20th-century genetics —so the geneticists keep telling us, and the Lysenkoites as insistently deny. How can we tell who is right? For one thing, we can note that the Lysenkoites, who founded their school in the mid-thirties on the rejection of 20th-century genetics, at the same time rejected work on inbred hybrids of maize,[1] which the geneticists had begun in 1908.[2] And the

[1] See the first number of the chief Lysenkoite journal, *Iarovizatsiia*, 1935, No. 1, pp. 45–46. Attacks on inbreeding were a recurrent feature in succeeding issues.

[2] The story has been told frequently. See Shull's account in J. W. Gowen, ed., *Heterosis* (1952); cf. also E. M. East, 'The Distinction between Development and Heredity in Inbreeding', *American Naturalist*, vol. 43 (1909).

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Lysenkoites kept on rejecting this type of work until the success of the new hybrids in America became so overwhelmingly obvious that they were endorsed by the CPSU central committee. That was in 1956.[3] Now the Lysenkoites have been obliged to recognise the achievement, but they reject the geneticists' explanation of it, though they cannot offer a convincing one of their own.

We may therefore conclude that 20th-century geneticists saw something that made it possible for them, and virtually impossible for those who rejected their insight, to create inbred hybrids of maize. Or rather they had two basic insights. They discovered that forcing maize to inbreed maims, sterilises, stunts, or depresses the offspring, but does not otherwise harm them, that is, does not harm their hereditary essence, their genotype. Second, they discovered that the blend of hereditary characters in maize is actually composed of discrete units, which can be separated by inbreeding and recombined in new patterns by crossing. To the Lysenkoites both these propositions are metaphysical nonsense. To the cornbreeder they have been immensely significant. Without fear of doing irreparable harm to his stock, he can use extended inbreeding to sort out its very mixed-up hereditary characters. As these characters become isolated in inbred lines, the undesirable ones can be discarded and the desirable ones combined by renewed, controlled crossing. What is more, some crosses of inbred lines are more vigorous in growth and higher yielding than the original open-pollinated varieties from which the inbred lines were derived. The increase in yields is great, between 25 and 35 per cent on the average, but it lasts only for the first generation of crossed inbred lines. The farmer has to buy fresh seed every year. Why this should be so—why inbred lines are always less vigorous than the open-pollinated varieties from which they derive, yet crosses of these inbred lines are often more vigorous; why crosses of the original open-pollinated varieties cannot produce the same degree of hybrid vigour or heterosis as crosses of inbred lines, and why this heterosis should fall off sharply after the first generation of hybrids—these are questions that geneticists still have not answered to their common satisfaction. One finds them constantly shaking their heads over the 'purely empirical', 'trial-and-error' development of inbred hybrids.[4] Such grumbling is often cited by Lysenkoites to prove that geneticists cannot claim inbred hybrids as their creation, but the grumbling actually proves the opposite. Relentless self-criticism is one of the hallmarks of the creative scientific mind; we can be sure that any breakthrough to a better understanding of heterosis will come from geneticists worrying over their present concepts, not from Lysenkoites, who almost never criticise their own doctrines.

IT was not only the new science of genetics that was necessary for the new programme of cornbreeding. A new kind of agriculture was necessary, and with it significant changes in the national economy as a

[3] See *Kukuruza*, 1956, No. 1.

[4] See, e.g., various essays in Gowen, op. cit.

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whole, and that required changes in the mental attitudes of farmers, officials, and the general public. When the first of the new inbred hybrids were being developed in the twenties, even Henry Wallace was troubled by the old rule that yearly purchases of seedcorn are the mark of an improvident farmer on the way to ruin. In the first edition of his famous handbook on corn Wallace also reflected the prudent farmer's doubts about industrially produced mineral fertilisers, yet they have proved to be absolutely essential as inbred hybrids began draining the soil of mineral nutrients at a faster rate to produce their higher yields. Willingness to make these large new outlays each year depended on the balance of prices between the seedcorn and the fertilisers, on the one hand, and the expected crop on the other, and this balance was determined not only by the biological qualities of the new seed and fertilisers but also by the economic characteristics of the society within which the new seed programme developed. The role of the government has been crucial. In subsidising basic research and the production of inbred lines, in maintenance of seed quality, in education and extension services that break in farmers to the new methods, in juggling price supports, taxes, and the other economic levers that synchronise—more or less—the whole complex mechanism—in all these ways government becomes the co-ordinator of the intricate interaction between science and agriculture. Interaction, it must be stressed, for the pure geneticist is not wholly independent, as some writers like to imagine; needing the money and the good will of the public, he depends on the economic success of the complex enterprise that depends on his original ideas. It would be interesting to discover what role has been played in this process by the traditionally individualistic ideology of the United States, and how much the process has altered the ideology.

For the Soviet Union, with its veneration of science and insistence on centralised planning, the new programme of cornbreeding seemed made to order. 'We have not the slightest doubt', a Soviet cornbreeder wrote in 1931,

> that in our conditions, with all the rigorousness of *khozraschet* [Soviet cost accounting], the problem of using [inbred] hybrid seeds profitably will be solved far more expeditiously than in America. . . . [Our price for this seed will be far lower than the prices charged by American profiteers.] Furthermore, in our organised system of seed production hybridisation will be carried out far more simply and harmoniously than in the disconnected individual enterprises of the American seedman and farmer. (*Semenovodstvo*, 1931, No. 9–10, p. 6.)

These brave words were written in the midst of an intensive nation-wide drive to breed a wide range of the new hybrids for a wide range of new areas into which corn was then being pushed along with collectivisation. By 1934 the drive to expand the acreage under corn was quietly abandoned, and along with it the nation-wide effort to breed the new hybrids. Only two or three stations continued to work on inbred hybrids, and that

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on a greatly reduced scale.[5] Mass production of such seed simply could not be organised in the chaotic conditions of the newly collectivised villages. Even if it could, the new farms were as likely to profit by yearly purchases of hybrid seed as the contemporary American unemployed were likely to escape from poverty by buying shares of stock.

The Bolsheviks did not ask themselves what light the practical failure of this early corn campaign shed on the biological and social theories that had inspired it. A rational answer would have been that the biological theories were not at fault; inbred hybrids of maize were beginning their rapid spread through the American countryside just as they were being abandoned in the Soviet Union. A rational answer would have been that Marxist-Leninist social theory, as interpreted by Stalin, had helped to inspire the corn campaign but had also helped to wreck it, by whipping up frenzied efforts to get farming going by hasty and ill-considered decrees. But the Bolshevik government was not prepared to blame itself or its ideology for this or for any of the agricultural fiascos that accompanied collectivisation. The formula on theory and practice was not to be turned against Marxist-Leninist theory or its chief exponent; after all, Marxism-Leninism was intended to inspire Bolsheviks with self-confidence, not self-doubt. The government blamed the peasants, or rather, 'kulak agitation against corn',[6] and showed an ever-mounting irritation with agricultural scientists, who were using large sums for research and education but could not stop the steep decline in yields.[7] The way was opened for an attack on the biological theories of the scientists. It was they who had been tried and found wanting, Lysenko began to argue.

IT is thus no accident, as the Marxists say, that Lysenko's school, which puts a scientific glow over primitive and retrograde farming, dates from the turmoil and disappointments of collectivisation. A wheat specialist to begin with, Lysenko came to inbred hybrids of maize only in 1935, as a result of his drive against the sexual habits of wheat. Lysenko's intuition told him that wheat's natural habit of inbreeding causes it to degenerate. Millions of peasants, each carrying a pair of tweezers, must be sent through the wheat fields stripping open the florets, forcing them to crossbreed. This proposal embroiled Lysenko in argument with genuine wheat experts, who proved that his 'intravarietal crossing' was either useless or harmful, and also with geneticists, who had convinced themselves long before that inbreeding does not damage the heredity even of natural crossbreeders like maize. Soviet officialdom threw its support to Lysenko, making the point that he and his school had useful proposals

[5] See *Selektsiia i semenovodstvo*, 1946, No. 1–2, pp. 36–37, for one of the few historical references to the corn campaign of the early thirties. The extensive contemporary evidence will be analysed in the book I am preparing.

[6] *Sotsialisticheskaia rekonstruktsiia selskogo khoziaistva*, 1930, No. 6, p. 78.

[7] See *Pravda*, 3 August 1931, for the first major evidence of this irritation—a decree on plant breeding issued by the Party's Control Commission and the Commissariat of Workers' and Peasants' Inspection.

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for Soviet agriculture, while his opponents had none, however erudite and scientific their theories might seem.

Practical usefulness to agriculture was to be the test of biological theory. Inbred hybrids of maize could hardly be offered in defence of genetics, for they required much more efficiency than the Soviet agricultural system could then provide—an argument that would hardly win the favour of Soviet officialdom. Only one corn specialist was frank enough to make this point, though indirectly:

> These varieties [inbred hybrids], for reasons of an organisational-technical nature, do not as yet have a chance of rapid acceptance, in spite of their increased productivity and high quality of grain. With the organisation of a harmonious [*stroinoi*] system of seed production these difficulties will naturally be overcome to a significant extent. (*Selektsiia i semenovodstvo*, 1936, No. 10, pp. 37–38.)

To press such an argument would have been to defend genetics by attacking the Soviet agricultural system. One can therefore understand the weak self-defence put up by scientists like Professor Vavilov when he was charged with failure to aid Soviet agriculture and forced from the presidency of the Academy of Agricultural Sciences.[8]

But what practical benefit did the Lysenkoites bring to Soviet maize? When the agronomist A. S. Musiiko launched a campaign to check the depressing effect of hot dry winds on fertilisation and seed set, Lysenko recognised a kindred soul, and made him his chief corn specialist. Musiiko got peasants to go through the cornfields when the tassels were dropping pollen, not with tweezers to be sure, but with pieces of rabbit fur, touching them from tassels to silks. Musiiko's original explanation was the modest and obvious one: the peasants were replacing pollen killed by the hot dry wind. Lysenko taught him to see profound theoretical significance in this additional pollination:

> Proceeding from Darwinian theory, one must draw the conclusion that free cross-pollination, especially of cross-pollinating plants, always, as a rule, leads to the receipt of a greater quantity of seeds from the plants, and also to their greater biological fitness and viability. (*Sotsialisticheskoe zemledelie*, 20 October, 1938.)

Additional pollination increased the plant's chances of choosing the pollen most suitable to itself, Lysenko reasoned. Repeating such arguments, Musiiko became the chief opponent of inbreeding as a method of corn improvement. In its place he and Lysenko justified continuation of old-fashioned methods: mass and individual selection within open-pollinated varieties, and efforts to achieve hybrid vigour by crossing such varieties.

[8] See *Spornye voprosy genetiki i selektsii* (Moscow, 1937), pp. 52–53, where Lysenko taunts Vavilov for his failure to produce evidence of the practical usefulness of in breeding. See p. 33 for Vavilov's brief defence of inbreeding at this crucial conference of December 1936. Note his failure to mention inbred hybrids of maize, even though he had received a full and enthusiastic report on their progress from the US Department of Agriculture. See exchange between Vavilov and Richey, 5 and 25 November 1935, in the US National Archives.

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They argued further that open-pollinated varieties could be grown much closer to each other than the existing rules allowed—does not each plant select the pollen best suited for it? The rules were duly changed, simplifying Soviet corn production even more, by further retrogression in seed quality and varietal purity.

In 1939 Musiiko and his friends got a conference of corn breeders to endorse their methods as the chief means of corn improvement.[9] A handful of cornbreeders nevertheless continued their quiet work with inbred lines. Within a few areas of the country they had some inbred hybrids certified and used by local collective farms. At the end of the second world war it even looked as if they might win a major victory over the Lysenkoites. The central committee called for a great increase in corn acreage as part of the effort to overcome the agricultural setback that the war had caused. The advantage of hybrid corn was stressed, though the decree did not specify inbred hybrids. Still, there must have been a high-placed decision to revive them, for Lysenko himself conceded their usefulness in a speech to the Academy.[10] (He had become its President in 1938, his two predecessors having perished as 'enemies of the people'.) There were other signs in 1945–47 of a resurgence of standard biology but it was stopped short. In August 1948 came the most spectacular conference biologists have ever seen, or are ever likely to see. With the explicit sanction of the central committee standard genetics was totally condemned. In the aftermath another conference of cornbreeders endorsed the Lysenkoite programme, and explicit orders to cease inbreeding were given even to such specialists as B. P. Sokolov, who were willing to endorse Lysenko's theories if only he would tolerate their work with inbred lines. And even so, it seems, they continued inbreeding on the quiet.[11] Dudintsev's fictional revival of the critically thinking lonely rebel was preceded by a revival in fact. In fact as well as fiction honest dedication to technology embroiled men with political authority.

Although the ban on inbreeding was quietly removed a year or so before Stalin died, the big resurgence of standard cornbreeding came after that momentous event. After Khrushchev had publicised the terrible state to which Stalin had brought agriculture, he raised a cry for corn, corn, corn everywhere, with the same unconcern for weather and economic calculation that had marked the similar campaign of the early thirties. But this time there was no general fiasco. There were poor initial results in some places, and corn may still be an uneconomic fodder crop in many areas where it is now being raised. We cannot tell from studies published so far, and it may be that Soviet agricultural officials themselves do not know; their science of agricultural economics

[9] See report in *Iarovizatsiia*, 1939, No. 5–6.

[10] Lysenko, *Agrobiologiia* (Moscow, 1949), pp. 592–593. The central committee's decree, on which Lysenko was discoursing, appeared in *Pravda*, 28 February 1947.

[11] See Mark Popovskii, 'Selektsionery', *Novy Mir*, 1961, No. 8. Popovskii ignores Sokolov's willingness to endorse Lysenko's doctrines. His heroes, like Dudintsev's, are purely heroic.

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is still at a fairly primitive stage. But in their arguments over the prices and bonuses that should or should not be paid for this or that kind of seedcorn, one sees clear signs that the inbred hybrids are profitable, at least in some sections of the country.[12] There are also, to be sure, continuing signs of inefficiency, but no longer so great as to make the production and distribution of inbred hybrid seed an impossibility. (The inefficiency is seen most vividly in the eagerness that Soviet corn specialists show for the development of inbred lines with cytoplasmic male sterility, which may be considered a labour-saving device, for they do not require detasselling. American seed companies have proved cool to this method, calculating that it entails a greater increase in costs of scientific personnel and acreage than it saves in costs of unskilled labour, mainly students and housewives. Soviet agriculture has an enormous surplus of working hands, yet their corn specialists never stop complaining that detasselling is not done well enough or in time.) The statistical tables show not only an enormous increase in the acreage under corn, but also a sharp increase in yields per acre, a much higher increase than most other Soviet crops can boast.[13] Undoubtedly the inbred hybrids are the major cause of this upturn in yields per acre. The Lysenkoites have ceased attacking them, and even show signs of backing away from such long-cherished dreams as the creation of open-pollinated hybrids that could compete with the inbred hybrids.

FROM 1955 to 1958, standard biologists were free to criticise the Lysenkoites in print, and quite naturally they harped on the Lysenkoite record in cornbreeding, for here the Marxist-Leninist formula on theory and practice would seem to have unambiguous application. The central committee, the final judge of successful practice, had endorsed a programme of cornbreeding drawn up by standard geneticists; surely their theory was vindicated and Lysenko's refuted by the ultimate standard, practice. But in 1958 the editors of the chief anti-Lysenkoite journal were dismissed. Since then only an occasional, exceptionally brave critic has dared to make printed reference to the Lysenkoite record in cornbreeding, while the Lysenkoites have poured out a stream of incredible distortions, designed to prove that *they* found the way to inbred hybrids, and that standard geneticists who occasionally contributed to this work were lucky empiricists who knew not what they were doing.[14] The highest Party authorities seem determined, for the moment at least, to protect the Lysenkoites against judgment under the law that scientific theory stands or falls as it serves or fails to serve practical needs. How is this to be explained?

[12] See, e.g., *Vsesoiuznoe soveshchanie po proizvodstvu kukuruzy, Krasnodar, 1960* (Moscow, 1961), *passim*.

[13] The most recent data are in *Vestnik statistiki*, 1963, No. 9, p. 83.

[14] See, e.g., N. I. Feiginson, *Korpuskuliarnaia genetika; kriticheskii obzor* (Moscow, 1963), pp. 376 ff.

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I would suggest three reasons. Lacking the space (and the archival evidence) necessary to prove them, I will merely deliver them in oracular fashion as three laws.

First is the law of the moral factor in science. Scientific careers are made by commitment to the cause of truth. Ask any eminent man of science if his own career does not prove this. Since most of the men at the top of Soviet biological and agricultural research and education got there by twenty or thirty years of service in the Lysenkoite cause, it follows that this is the cause of truth. Only disgruntled failures and cranks will see here the operation of a self-serving faction.

Second is the law of muddling in politics. Clearcut decisions hurt, muddling soothes. The central committee could reassert its supreme authority in science clearly and unmistakably, either for the Lysenkoites or against them. Alternatively, the central committee could explicitly renounce its competence in biology and agronomy, as it did recently in medicine (*Pravda*, 1 August 1962). Either one of these would be a clearcut decision and would hurt many people and interests. Perhaps the greatest difficulty is that either alternative would make it very difficult to avoid public discussion of the central committee's record as the supreme judge of successful practice and therefore of scientific theory. The central committee still refuses to be judged by its own formula on theory and practice; it prefers to muddle along, inclining now towards one alternative, now towards the other.

Third is the Soviet version of Pope's famous law: a little knowledge is more dangerous than none at all. (In America this reads: executives know better than the specialists who work under them.) Since the thirties large areas of Soviet technology and science have been bossed by the half-baked executive specialist, the man who knows enough of a subject to play the authority so long as political and technical authority are confused. The formula on theory and practice justifies the rule of such men. Not Lysenko but Khrushchev is the prime specimen. He fancies himself a specialist in agricultural policy, a Soviet version of Henry Wallace, and many people take his pretensions seriously. Such people should reflect that Khrushchev hasn't the foggiest notion of the connection between the new hybrids of maize and the science of genetics. He thinks he can have a successful cornbreeding programme while education and research in basic genetics are starved and humiliated by Lysenkoite officials. The simplest way to understand Khrushchev's qualifications as an agricultural specialist is to read how he reversed the experts on the suitability of corn in the Moscow *oblast*. For two summers he raised it successfully in his *dacha* garden.[15] He has either heard nothing of randomised field trials over a period of years, or he retains the Stalinist contempt for statistical reasoning as camouflage for bourgeois specialists and lazy peasants.

Finally, I would give a warning against hasty generalisation. I have

[15] A. S. Shevchenko, *Kukuruza* (Moscow, 1960), pp. 16–17.

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tried to show the formula of theory and practice at work in Lysenko's maize. The formula has had strikingly different application in other fields of practice, in theoretical physics, say. The reader may be startled by the inclusion of theoretical physics in the realm of practice. But he should realise by now that ' theory ' and ' practice ' are highly ambiguous terms in Soviet thought. In any case, the central committee is the ultimate judge of the lessons of practice, not Western students of Soviet history. If one accepts that, then the rest is not hard to understand. The failure of the hybrid corn programme in the early thirties did not demonstrate the inadequacy of the Soviet agricultural system and the social theory that inspired its hasty creation. The apparent success of the same programme since 1956 does demonstrate the efficiency of the agricultural system and the truth of the social theory that inspires it. The failure of the early thirties demonstrated the practical uselessness and therefore the theoretical falsity of standard genetics, but the success of the past eight years does not reverse that verdict. Lysenko's shabby record in corn improvement demonstrates nothing, for it is denied and forgotten.

In all this confusion there is one element of unambiguous meaning, which Stalin gave to the old Marxist formula on theory and practice: politics is the highest type, the summation, of practice, and the authority in political practice is thereby equipped to judge all lower types. One may hope that practice in the widest sense, the requirements of a modern society, will continue to erode this Stalinist belief, as it has done already, though incompletely, with respect to Lysenko's maize.

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BIOLOGIST IN MOSCOW

H. Mohr

MY trip to Moscow was made possible by the exchange of scientists between the German Federal Republic and the USSR, provided for in the cultural agreements between the two countries. I was warmly welcomed by the Russian scientists, despite the tense political situation and the weight of official propaganda, which again and again denounced the Federal Republic as the blackest of all black sheep.

My stay was well organised. The programme proposed was flexible and of a general nature, so that all my wishes with regard to visiting certain institutions were respected. I saw only biological and, in particular, plant physiological institutes, and therefore my comments must be confined to these. The particulars which I give are based on my own observations and on the information given to me by my Russian colleagues.

As a guest of the Academy of Sciences I stayed in one of the large new hotels, in which the guests were almost exclusively foreigners. The staff were very friendly, but one should not apply the same criteria to Russian hotels as to those in Western Europe or the USA. Despite the large personnel the hotels never seem to run smoothly; one of the two lifts was generally out of order, and the serving of breakfast was usually a serious problem. In fact, having any meal in a Russian restaurant is generally an extremely lengthy and complicated business.

During my entire stay I had an interpreter at my disposal, and on the long journeys a car provided by the Academy. My interpreter, a student of biochemistry, spoke English and German very well; he had mastered all the technical expressions, so we never had any language difficulties in this respect. Direct conversation with our Russian colleagues was often possible, mostly in English. We talked mainly about scientific topics of mutual interest, but sometimes we also discussed questions concerning private life, such as the standard of living, or questions of a political nature.

Probably the reason why I established contact so quickly with the Russian scientists was that I already knew a lot of them personally from international conferences, or had at least exchanged publication offprints with them. Another essential condition for a successful visit is an adequate knowledge of the pertinent literature, which today can always be acquired with the help of American translations. The Russian scientists are sometimes rightly grieved that many of their works, especially those of a high scientific value, are simply not acknowledged in the West.

We all know that the general standard of living in the USSR is much lower than in Western Europe or in the USA. Russian scientists, however, are seldom well-informed about conditions outside, with the exception perhaps of those who have been in the West to attend

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conferences; but they assert again and again that they are prepared to accept their present standard of living since it is steadily rising. This is indeed the case, and every year the upward trend is accelerated. In any case, the members of the research institutes and the university professors of natural science and technological subjects are relatively well paid. I was told that their income is about eight to twenty times higher than the average income of a worker (50 to 80 new rubles).

In my experience the lack of objective information, which the Western visitor finds so disagreeable (e.g. one cannot buy any foreign magazines or newspapers other than communist papers like *Neues Deutschland* or *The Daily Worker*) has also unfortunately meant that the political horizon of many scientists is very narrow. One is all the more astonished by the warmth of the welcome and the kind treatment accorded to the visitor from the West.

Timiryazev Institute for Plant Physiology

This is an institute of the Academy of Sciences of the USSR, and it the most important scientific establishment in the field of plant physiology in the USSR. Its director is Academician Kurzanov. Built in 1934, it now consists of 10 departments with a total of about 520 scientific workers and assistants. These departments are partly in the old institute building in the town, and partly in a modern institute building, called 'Phytotron' after the American model, in the suburbs of Moscow. The most important departments are the following: photosynthesis research, growth and development physiology, water economy, ion absorption, heat and salt resistance, frost resistance, transport of organic compounds, physiology of storage, growth promoters and inhibitors, ecology.

The primary task of the institute is to gain new insights into plant physiology for the improvement of agricultural techniques, e.g. research into heat resistance aims at developing practical methods which will enable heat resistance of agriculturally cultivated plants to be increased in suitable areas. Although the closest possible contact between theoretical and practical physiology is certainly sought, there is still enough room for such basic research as cannot be found to have any immediate use. 'We are trying to gain the widest possible knowledge of plant physiology; many valuable uses then emerge automatically.' This way of thinking seems to me to be typical. Indeed, with regard to the supervisory stages, experiments are carried out on cultivated plants whenever possible.

With the new phytotron, the departments of the institute are adequately equipped for their tasks. Unlike many participants at the International Biochemistry Conference in Moscow in August 1961, I did not gain the impression that the scientific work of the biological institutes was seriously curtailed by their apparatus and equipment. Granted that in the old part of the Timiryazev Institute there is

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sometimes a distinct lack of space and also many deficiencies. In the new phytotron, however, they have tried and are still trying to turn to good account the experiments which have been carried out in other countries, particularly in the USA, on the construction of large climatic ground for plant cultivation in completely controlled conditions, e.g. the experiments of the Earhart Laboratory in Pasadena. These copied experiments are not always successful, and the Moscow phytotron seemed to me much less practical than its American counterpart; nevertheless it represents, even by international standards, a very remarkable research establishment in plant physiology. Its experimental potential is at the moment at least the same as ours.

The apparatus rooms in the phytotron are well equipped. Everything that is generally needed by way of physical apparatus in modern plant physiological research is provided, from the flame photometer to the automatically registering spectrophotometer. I cannot of course judge how well the apparatus functions. Most of the apparatus is made in Russia or in the Soviet bloc; some of it comes from the West. I was told that during the course of the present seven-year plan larger sums of money have been allocated for the improvement of the apparatus and basic equipment. The phytotron, too, is being extended.

I was struck by the relatively large amount of apparatus built in the institute's own workshops. This often appears simple and unattractive but, as far as I could judge, it functions satisfactorily. This practice has become widespread because the fairly rigid economic planning does not provide for the construction of much necessary equipment in factories. The Russian talent for improvisation apparently plays an essential role in overcoming technical difficulties.

Astonishingly good results are generally achieved with the equipment they have, at least in the fields with which I am especially familiar, photobiology and developmental physiology. This is clear from the work published in the most important plant physiological-biochemical journals of the Soviet Union, which can now be obtained in English translation. Whether a well-equipped institute has the character of a museum or whether the technical potential is being fully exploited naturally depends, in the Soviet Union just as with us, on the scientists who work there. In this respect the staff of the Timiryazev Institute made a good impression on me. Besides the well-known older scientists like Kurzanov, Nichiporovich, Chailakyan, Henkel, etc., I met a number of very able, rather specialised young scientists who, by our standards, are exceptionally well trained in the modern technical spheres of biochemistry and biophysics. They must be given credit not only for maintaining the present level but also for raising it quickly. As one of the older departmental heads assured me, they consider it very important that members of the young generation with a good knowledge of modern methods of physiology attain as quickly as possible positions in which they can help to determine the course of future research.

The relationship between individual scientific work and team work is

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similar to ours. The essential difficulty—as everywhere in the scientific world—lies in finding the right compromise between specialisation and integration ability. I gained the impression that many of the young Russian scientists were unusually specialised. On the other hand, a few (such as my interpreter) seemed to have an excellent general training in the natural sciences.

I got along very well with my Russian colleagues of the Institute not only in regard to technical and methodological questions, but also in regard to general scientific problems. Their scientific aims are compatible with ours, e.g. with regard to research in photosynthesis and photomorphogenesis, and in general plant development. Of an ideological dogmatic bias, often attributed to Soviet biology, I could at most detect faint traces in the fields of especial interest to myself (e.g. in connection with the theory of phases). In the fields of cytology and genetics the dangerous influence of Lysenko on Russian genetics seems to be gradually disappearing. Recently, however, Lysenko has come more to the foreground since taking over the Presidency of the Lenin Academy of Agricultural Sciences, but he has probably lost his dominating position within theoretical biology.

The atmosphere of the scientific conferences in which I took part was very similar to that in Western Europe and the USA. In the forefront is the interest in biological phenomena, which they attempt to describe physiologically or with a physical or chemical bias; for example, Dr. Nichiporovich and his group have, during the last few years, come to the same conclusions about the influence of light on the protein synthesis in the photosynthesising cell as my own group, although they used completely different methods and quite different plants. Thus I was able to speak about these problems directly with my Russian colleagues in long and extremely interesting discussions, and we were able to agree on a theory acceptable for both parties. The Russian scientists again and again stress that they are anxious for international cooperation and hope that relations between scientists will serve as an example for politicians.

Scientific competition between East and West does exist in biology. Whether the scientific race in this sphere of the natural sciences will in the future assume a political aspect, as it has in some spheres of physics, remains to be seen; it is not impossible.

Plant Physiological Institute

I did not receive a particularly good impression of this institute of the Timiryazev Academy, where I spent only a relatively short time. Technically it is out of date, and it is also more poorly equipped than the Institutes of the Academy of Sciences which I visited. I visited it chiefly because it was there that Dr. Leman did a number of good photobiological studies. He must have been a master of improvisation to have successfully carried out such fine experiments with the modest

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photobiological equipment available in this old institute. A further reason for including it in my schedule was that Professor Gunar and Dr Krastina, now on its staff, are working on endogenous rhythms, which in the last few years have become recognised fields of study in biology in Europe and in the USA. Detailed discussion with Dr. Krastina revealed that, in principle, research into endogenous rhythms is being carried out, in regard both to theory and method, in a similar manner in the Russian as in a Western institute. Objective facts are noted (e.g. bio-potentials), and interpreted in a way which would be possible with us too. Cybernetics has played an important part in shaping attitudes.

Biophysical Institute of the Academy of Sciences

At the time of my visit this institute was in the process of moving to a new building. Despite this, its personnel and equipment made a good impression on me. The director of the institute, Dr. Frank, and some of his assistants, gave me an illuminating survey of the tasks and aims of the institute, which may be defined roughly as follows: they investigate biological systems according to methods and concepts used in physics. Such a view of biophysics is in complete agreement with our definition.

Besides good equipment (here too they make lots of their own equipment), the number of young scientists was striking, especially young physicists, whose excellent training was revealed in their conversation. The Academy of Sciences seems to put great emphasis on biophysics.

The institute is divided into a number of departments, of which I visited those for radiology and photobiology, as well as the laboratory for electronspin resonance. Under the right leadership (and Dr. Frank seems well qualified to provide this) this institute may well become an important research centre. Team work seemed to be indispensable here, as most of the young assistants are apparently trained in a relatively limited field. They are, however, well trained. This state of affairs, and the resulting problems, are, of course, by no means confined to Soviet institutes!

In this institute, too, I met an astonishingly large number of women among the scientific staff—I estimate about 40 per cent. This is far higher than would be found in the West, where only a few women embark on physics or a combination of physics and biology as their career. There may be some connection between this and the high esteem in which natural scientific subjects are held in Russia.

Biology-Soil Science at Moscow University

The Lomonosov (Moscow) University is the largest and most important in the Soviet Union. Its biological/soil science faculty has six departments with a total of 28 chairs, of which 22 are in biology. By extensive specialisation and division within the field of biology, the Russians are trying to master the traditional aspects of this subject as well as its

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modern requirements. Physiology and biochemistry are, however, in the foreground of the training given at the University. The great difficulties which increasing specialisation involves are, of course, also experienced by Russian scientists. One of the essential aims of biology training in the Soviet Union, as with us, is to preserve as far as possible a general overall view of the subject.

The department of plant physiology in which I preferred to linger is divided into three subjects—plant physiology in the narrower sense (2 chairs), biochemistry of plants (1 chair), microbiology (2 chairs).

Professor Belozerski, who holds the chair of biochemistry of plants, gave me a very clear picture of the organisation of the faculty and the course of instruction followed by those students who have chosen plant physiology as their main subject. It emerged from our discussion that the teaching schedule in biology is very similar to the diploma course started at Freiburg University in the winter semester of 1961/62. The same applies to the estimated value of mathematics or physical chemistry as scientific aids to biology. Certainly the students are trained and examined according to a much stricter plan than ours; they have to follow a clearly prescribed course. The Professor told me that the results are excellent. The majority of doctorates of the plant biological academy institute are taken by graduates of the department of plant physiology.

As the proportion of teachers to students is much better than with us (Belozerski put it at about 1:5), teaching, which they obviously take very seriously, is not hampered, and the teaching staff has particularly modern and comprehensive chemical and physical equipment; this means that the work of the laboratories is not limited by lack of equipment—all the necessary major apparatus is there; some of it is made in Russia and some imported from abroad. Most of the research, however, is done by the scientists of the Academy Institute, who, apart from minor lecturing duties, devote themselves exclusively to research. Training of students is regarded as the university's main task. According to Professor Belozerski, the majority of doctoral theses originate in the institutes of the Academy.

The arrangement of the lecture theatres is excellent, but many rooms are cramped, suggesting that, despite the larger building, problems of space have again arisen.

The professors are not too heavily burdened with teaching duties, and have some time for their own research and for close study of the literature in their field. Although they have a six-day week, the tempo of work is much less strenuous than with us, which must be good for the health of the scientists and makes for a better performance in the long run. My reference to the customary 70-hour week of our professors was received with horror.

From conversations with biologists I gained the impression that both the teaching and studying were of a high standard. On the average the students, many of whom are girls, seem to be of a high intellectual

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calibre. A strict curriculum stretching over 5½ years concludes with a final examination which can be roughly compared to our diploma. Of these 5½ years only the last 2½ are devoted to a specialised field. Great emphasis is laid on a wide knowledge of exemplary original works; a kind of independent study which, at least in our subject, is much preferable to straight textbook study. Most students then begin practical work, after which they can embark upon further training under the direct supervision of a professor. A theoretical and experimental thesis qualifies a student for the title of 'Kandidat', and finally, after a few years as an 'Aspirant', he is eligible for the 'Doktor' title, for which he must submit a number of his publications.

I can say nothing from first-hand observation about the arts faculties, but from the remarks of the natural scientists I deduced that natural science students represent an elite. It is not only interest in the natural sciences that attracts the talent students, but also the relatively good salary which they will later receive in their profession.

Conclusion

It seems to me to be of the greatest importance that we should encourage more frequent and more widespread exchanges between scientists of the Western world and the USSR.

My impression was that Russian biology has more potential than we commonly think; the Lysenko affair seems to have been set aside once and for all. It does not look as if biological research is being handicapped and restricted by political dogma, although traces of this are still everywhere to be found. I was particularly impressed by the educational system of Moscow University, which has recently been adapted to modern requirements. The result in the long run must be a larger number of well trained young biologists. Apparently the natural sciences are valued much more highly in the Soviet Union (by the public as well as by the educational system) than in the Western world. This positive attitude is connected not only with the direct importance of natural science for technological and economic affairs, but also with their recognition of the natural scientists as a constituent of 'culture', at least to the extent in which they are in agreement with Marxist-Leninist philosophy. Many Russians are apparently convinced that the present and future differences between the Eastern and Western world will be settled primarily in the laboratories and lecture halls, and that Russian scientists in the coming decades will surpass the Western countries in other spheres of natural science as they have done in some fields of physics. To accomplish the national and international aims of the Soviet Union is seen as the chief task before the natural scientists and the technologically trained, or at least 'educated' intelligentsia.

It is obvious that the dispute between East and West is developing more and more into a scientific race. It is possible that in the foreseeable future the Russians will be better prepared for this than Germany or

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the other countries of Western Europe, where a hostility to science is often regarded as the proper attitude of the intelligentsia. A remark made by an official of the Academy of Sciences in Moscow has stuck in my memory: 'Physics were the most important scientific field in the first half of the 20th century, biology is likely to assume this role in the second half'. One may share this opinion or not; at any rate, it was interesting to hear this assessment of the present scientific situation from a political official.

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SOVIET MEDICINE

(1) Research and Public Health

Robert Roaf

WHEN one discusses events in another country it is difficult to avoid the impression of comparing such happenings with similar occurrences in one's own country, with which inevitably one is more familiar. One could, in theory, merely note differences without indicating either approval or disapproval, but it would be a confession of failure if one did not at least try to assess in what way one could learn from the way things are done in other countries; one must equally avoid thinking or saying, or even seeming to say, that something is either better or worse just because it is different.

In discussing Soviet medicine there are of course many difficulties; in the first place one's knowledge is almost certainly inadequate, and although I have visited the Soviet Union on four occasions it is clear that I have only seen a very small portion of it, and my generalisations must be based on a very inadequate sample. Secondly, it is clear that I may have misunderstood the significance of the things I have seen. Thirdly, it is extremely difficult to appraise any country's medical services. Is the British National Health Service a good thing or a bad thing? Has it led to better or worse services for the average patient? There are no objective criteria by which one can assess medical services. In industry or agriculture one can measure total output, output per man per hour or per acre, and the cost of the finished product; but such criteria cannot easily be applied to medicine. Important vital statistics such as the mortality rate, the morbidity rate, and the expectation of life, probably depend more on economic, social, and hygienic standards than on direct medical care. Should one then judge the efficacy of medical services purely in terms of a patient's satisfaction? Here again one knows of many instances where patients have been extremely well treated and remain dissatisfied, and just as many where the clinical result has been poor but the patient has been very pleased. The purpose of medical services is to ensure that all patients receive the right treatment for conditions for which there is a known cure, and that they do not receive harmful treatment and are treated with kindness and consideration by doctors, nurses, and medical auxiliaries: in addition, the purpose of hospitals is to train doctors and nurses and to do research into the causes and cure of diseases.

It is of course fairly easy to say that a hospital is bad if it is dirty or unhygienic, if there is a high rate of cross-infection, or if the staff are inconsiderate to the patients. But it does not necessarily make a hospital good or bad if the wards are large or small; local customs and habits often determine items such as details of accommodation or treatment which may seem very important to us but are not necessarily of great

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significance; for instance, we may consider a hospital overcrowded just because its arrangement is different from what we are used to in this country.

THE first line of defence of the Russian medical services is the poly-clinic; this is served by a number of doctors who have specialised in different aspects of medicine; at a typical poly-clinic there may be three or four specialists in internal medicine, two surgeons, two gynaecologists, a radiologist, a pathology, an eye, skin, and E.N.T. specialist, and a number of medical auxiliaries. A poly-clinic deals basically with ambulatory outpatients and with treating minor injuries; essentially it is a cross between a health centre and a hospital outpatients.

Poly-clinics may be situated at a school, a factory, or in a large block of residential flats. Most of the doctors work on four to six-hour shifts and a high percentage of them are women. I have been told that some of the doctors will work in two different poly-clinics, that is, they do a double shift during the day. The rate of pay is relatively low, that is, comparable to what a semi-skilled worker might earn in heavy industry, but it is usually less than what a skilled worker or a first-rate coal-face miner would earn.

In the rural districts the arrangement is somewhat different; usually there would be a health centre in which a senior doctor, a junior doctor, and two or three nursing assistants work. If the patient's condition is complex or if he does not respond to treatment, he will be referred either to the district general hospital or to one of the specialised institutes. Most hospitals do not have outpatient clinics in our sense of the term; in other words, if a patient is referred to them, he or she is admitted; similarly after discharge the patient usually continues further attendances at his local poly-clinic; outpatient follow-up clinics at the central institute were unusual. In a large country this is usually inevitable; it should be noted that in many of the hospitals patients have come from vast distances and will therefore stay in hospital in the convalescent phase rather longer than they would normally do so in England. The general hospital exists basically to serve the local needs of each region, and for the most part the services are less specialised than in this country. For instance in the general hospital in Tbilisi, the surgical division treated all types of surgical conditions, traumatic, orthopaedic, gastric, urological, and other branches of surgery. The distinctive feature of the Soviet medical service is the specialised Institute which is usually better equipped and staffed than the general hospital. This policy of exalting the special Institute above the general hospital is in striking contrast to the policy pursued in this country. In most of the big towns there will be special Institutes for special branches of medicine and surgery, e.g. orthopaedics and traumatology, neourosurgery, cancer, etc. For the most part these Institutes will be generously staffed, and will be performing highly specialised work. In the field of orthopaedics and traumatology there are eighteen such Institutes

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situated in the major cities of the country. These are coordinated by the Central Institute of Traumatology and Orthopaedics in Moscow, and, just as the local Institutes guide and assist surgeons working in general hospitals if they have any special orthopaedic or traumatic problem, so will the Central Institute in Moscow guide and assist the work of the peripheral Institutes and act as a medium through which knowledge and information can be exchanged. Perhaps it would give one the best insight into the system as a whole if I were to describe one or two of the special Institutes in Moscow which I have visited on a sufficient number of occasions to obtain an idea of the work they do and how they run. Inevitably, my experience of Russian hospitals is limited and highly selective, being largely governed by the speciality concerning which I know most. But I am assuming, I think fairly, that the Institutes I describe are typical of the best of their kind.

THE Institutes I visited were on the whole generously staffed; for instance, at the first Moscow Medical School there are 50 Professors, at an adult poly-clinic we were told that there were 45 doctors to deal with a population of some 10,000 people, and at the principal children's poly-clinic in Tbilisi there were 250 doctors and 600 trained nursing sisters for a hospital of 1,300 beds.

The Central Institute for Trauma and Orthopaedics in Moscow is a new building, constructed on strictly functional lines without any of the unnecessary magnificence and excessive decoration which characterised the late 1940s and early 1950s. The hospital consists of ten major departments and each department consists of a corridor off which there are a number of small wards containing three, four, or six beds. In general, the beds are rather closely crowded but the patients appear happy and well cared for. In this, as in most of the newer hospitals, there are wash basins in each room: in each department there is a dining room for 'up' patients, and in some of the wards there are ear-phones, and a bed bell to call for attention. There are special rooms in each department for changing surgical dressings. We were told that there were six operating theatres and three recovery wards for post-operative cases. Each recovery ward had eight to ten beds. In this building there were 400 beds in all, there were ten separate departments, and a Professor in charge of each department with two assistants. The departments were somewhat specialised and had titles such as Sport Trauma, Ballet Trauma, Electric Burns, Tumours, Arthritis, Hand Surgery, Neuro Surgery, Children's Orthopaedics. In toto, the various hospitals composing the Central Institute contained 900 beds, with 80 doctors and 20 Professors. I was told that the Institutes were primarily for scientific study, and only patients of special scientific interest are admitted. For instance, in one ward we saw seven patients with the rare condition of congenital absence of the radius, all in one room. The Institutes advise the general hospitals and coordinate the scientific work of different Institutes.

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At the Central Institute extremely interesting work is being done on the transplantation of frozen cadaveric bone and cadaveric fascia, tendons, skin, and nerves, and we saw many cases of difficult tumours treated by widespread resection of bone and replacement by whole sections of preserved frozen cadaveric bone.

Part of the Central Institute of Trauma and Orthopaedics is the Moscow Orthopaedic Hospital under the direction of the doyen of Soviet orthopaedic surgeons, Professor V. K. Chaklin. Professor Chaklin's special interest is in scoliosis and spinal conditions, and he has devised a number of excellent operations for this condition, in particular a wedge excision of the lumbar vertebrae, for correction of lumbar lordosis. We had the pleasure of seeing him do one of these operations and were much impressed by the technique and the efficiency of the theatre team. Incidentally, almost as soon as the skin had been sewn up, we were shown frozen sections of material removed at operation: the sections were excellent and were prepared by a technician who, we were told, had only had one year's training. This hospital had been built before the last war primarily as a school, but with operating theatres so that it could be changed into a hospital in time of war; it has remained a hospital since.

In addition to patients from all over the Soviet Union we noticed a certain number of patients from countries such as Cuba and Syria.

At the Central Institute there are few emergency admissions, as most emergencies are admitted to special emergency hospitals, of which the oldest and best known is the Sklifosovsky Institute. This Institute is 150 years old and is housed in some buildings which were originally a home for the chronic sick and the elderly, to which a small sickbay was attached; it is interesting to note that the famous French military surgeon Larré used it for French troops when they occupied Moscow in 1812. We were told that there were 300 new attendances each day, of which 100 were admitted. Outside the hospital stands a fleet of ambulances which are really converted cars; it is customary for a doctor always to travel with the ambulance when it goes out to collect a patient.

The surgeon staff is divided into different special teams, e.g. gynaecology, oesophageal surgery, gastric surgery, arterial surgery, fractures, head and face surgery; on admission to the outpatients the casualty would be taken to the appropriate department. There was also an anti-shock room in the casualty theatre, but this was not as well equipped as the best reception rooms for severe casualties would be in this country; one had the impression that multiple injuries are less common in the USSR than here. Again, we noticed that the staffing was on the lavish side; the figure given was one doctor per seven patients, and one trained sister per fifteen patients; it was interesting to note that there was a woman doctor in charge of the swimming pool, which contained, when we saw it, three relatively fit men swimming about in it.

The special feature of the Sklifosovsky Institute is the use of cadaveric

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blood, developed by the great Russian surgeon Yudin. Incidentally, there is a beautiful museum on the top storey containing sculptured busts of well known Russian surgeons and other historical relics, among which are the Diploma and Robes of the Honorary Fellowship of the Royal College of Surgeons of England conferred on Professor Yudin during the 1939–45 war.

We asked a great many questions about the training of nurses, and were informed that girls were accepted as student nurses when they left school and had reached the requisite standard of education—usually at the age of 17 or 18. We were told that student nurses lived at home and were paid 20 rubles a month. The training course lasts three years; all lectures are given by doctors, but there are practical demonstrations by trained sisters. The examination at the end of the course is conducted by a committee of doctors and each hospital or training school conducts its own examination; there is no central examining and registering body. In most hospitals the Director of Nursing was a doctor.

After training the nurse is advised to take some highly specialised post; for instance, she might specialise in theatre work, or she might be trained as a medical auxiliary in radiography, physiotherapy, occupational therapy, bacteriology, biochemistry, or histology. Here again the training was highly specialised and one girl might be trained merely to administer a certain treatment, e.g. faradism, diathermy, or some specialised technique, and she would concentrate on this alone. As far as we could see there were no generally trained physiotherapists in our sense of the word.

We also visited the Central Institute for Prostheses. This contains beds for 150 patients, but the main part of the Institute is occupied with workshops, laboratories, and various excellent scientific supporting teams; for instance, designing rooms containing draughtsmen, gait laboratories, physiology laboratories, and we saw there amongst other things a variety of lower limb prostheses, and a springy artificial foot with the central core of limewood, surrounded by laminated rubber. We also saw the much discussed electric upper arm prosthesis: the principle of this prosthesis is that action currents are picked up from a patient's own muscles by means of surface electrodes, are amplified by the equivalent of a small transistor set, reinforced by a small battery running a small but powerful electric motor which converts the electrical energy into mechanical energy. I was impressed by the smoothness of operation and the ability to grade the force with which the artificial hand gripped objects. The battery is recharged from the mains every three days: 150 such limbs are in regular use and they have been reliable in practice. We were also shown a number of experimental devices incorporating both a flexion and extension of the wrist and rotation of the forearm as well as gripping with fingers and thumb. Here again the Central Institute conducts the fundamental research and the results are transmitted to other Institutes in other parts of the country.

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TRAINING of the specialist is in many ways different from that in this country. The aspiring specialist spends three years as an aspirant, getting his experience of general medicine and surgery; if he then decides to specialise—for example in orthopaedics—and is accepted for training, he will go to one of the Orthopaedic Institutes where he will work until he obtains his Doctorate of Medical Science. This is not based on examinations as in this country, but he has to conduct a piece of research and write a thesis. I had the opportunity of examining some of these theses, and discussing their findings with the successful candidates, and was much impressed with the high standard. A doctor of medical science is then eligible for an assistant Professorship.

There were other respects in which we noticed differences from this country; for instance, all cleaning appeared to be done by hand and there was a notable absence of mechanical aids to cleaning such as vacuum cleaners and floor polishers. Sterilisation appeared to be done locally in each ward and there was no central sterile supply department, nor had the use of disposable sterile articles such as syringes, paper towels, etc., come into general use, but in the more modern hospitals there were separate dressing rooms to which the patient was taken from his own ward to have his wounds dressed.

Nowhere did I see evidence of trained medical secretaries, and although at one Institute the notes were typed by the ward doctors, in general the notes were written in longhand, and I was unable to discover whether there was an efficient disease index system.

In general I could say that although there were fewer amenities provided for the patients than are usual in this country, the patients appeared happy and contented and well cared for. Relations between patients and staff appeared to be good. The staff themselves were obviously keen and enthusiastic and anxious for their patient's welfare, and they were keen to discuss all aspects of their work with visiting doctors such as myself.

One other notable feature of the Russian medical system is the provision of sanatoria; these are a cross between a hotel, a holiday camp, and a rehabilitation centre. Along the Black Sea littoral there are over one thousand of these, to which tired or convalescent workers can be sent for a holiday. The patient's activities are subject to medical control but the design of the sanatoria I visited was very good. The one in which I stayed had excellent food and provided first-class facilities for all kinds of sport, especially for young people.

In a rather brief and necessarily superficial survey one may well have missed several important points, but what I can say with some certainty is that the hospitals I saw were considerably better than those I saw ten years ago, and far better than the one I saw in 1935. The general standard of medical care appears to be rising; the number of doctors compared to the general population is increasing. Those I saw were well trained, intelligent people, full of interest in their work and showing consideration for their patients.

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At all the Institutes I visited there was a great emphasis on research work and the general atmosphere was most exhilarating. I am not competent to discuss Soviet scientific work in branches of medicine other than my own. Ten years ago I was impressed by the widespread influence of Pavlov on psychiatry and general medicine, and in this connection it is interesting to note the growth of interest in ' conditioning ' as a therapeutic agent in this country in the last few years. Although the importance of Pavlov's work on conditioned reflexes is still widely recognised in the USSR, these important ideas are now seen in their true perspective and are applied with more discrimination than was the case ten years ago. In this, as in many other things, the Soviet and Western points of view are now much closer together. I also got the impression that there was less research work on the development of new drugs in the USSR than there is here and in America.

It is not my business to say whether Soviet medicine is better or worse than English medicine. There are certain differences between the two systems and, especially in the provision of Central Institutes as centres for teaching and research, I think we have much to learn from them.

(2) The Oncology Service

D. W. Smithers

DURING OUR BRIEF VISIT to Moscow and Leningrad in the spring of 1961 we visited nine hospitals with their associated research institutes and had a long discussion on their cancer organisation in the Ministry of Health where many questions were put and freely answered. At the end of each long day (that is, after the visit to the ballet, opera, circus, or puppets) I wrote a detailed account of the events and recorded information gained. Much of this had to do with research projects, but throughout the tour the special nature of their cancer organisation was so apparent that, at our own request, we ended our visit with a discussion of this subject with one of the doctors in the Ministry of Health responsible for the oncological service. This allowed our impressions to be put to the test of direct questioning about intention, and for statements about policy to be seen in the light of our own observations.

The Soviet Ministry of Health believes that by creating a special service, calling it oncology, including all neoplastic disorders whether benign or malignant, supporting it with propaganda, and promoting concentrated, clinically directed research, they have done much to increase efficiency and reduce fear.

Main Structure

There are a number of specialist institutes, chiefly in Moscow and Leningrad, under the Academy of Medical Sciences of the Ministry of Health. These are highly privileged research establishments regarded

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as the spearhead for advance in the special subjects they represent. Their staffs are selected from the best brains available, they are well supplied with assistants; clinical, scientific and technical. They have plenty of laboratory space and, in general, excellent apparatus. Their research programmes include basic, clinical, applied, and operational aspects and are administered by doctors.

The directors of the institutes we visited were all active clinicians each controlling the administration and the clinical work and, usually through a deputy scientific director, the research programme as well. Under them individual directors of special units might have 30 to 60 beds and their own research laboratories and staff, as well as access to the general research laboratories within their institute. Whether these were called oncological institutes or radiological institutes seemed to make little difference to their general structure. The outstanding organisations were, however, the main institutes of experimental and clinical oncology in Moscow and in Leningrad.

The Herzen Institute of the Ministry of Health differed from the others in being independent of the Academy of Medical Sciences, and in having in addition to its fundamental and clinical research programmes a special responsibility for postgraduate oncological training and for the direction of over 200 oncological dispensaries scattered through the Soviet Union.

Doctors and the Service

A doctor wishing to join the oncological service must, officially at least, have first done 3 years in general practice. On qualification doctors are often directed to work in some less attractive part of the Soviet Union where posts might otherwise be difficult to fill. A system of merit awards works throughout the medical structure, starting with medical students, and an elite is selected for the special institutes. A few of the doctors in these specialist institutes seem to have been there since qualification. Posts in these institutes are advertised and hotly competed for. Promotion is highly competitive at all levels.

The Herzen Institute, in addition to its permanent staff, instructs specialists working in the distant dispensaries who return to the parent institute for postgraduate study at regular intervals. The Herzen Institute sends instructions to the dispensaries regarding methods of treatment, and also sends frequent visitors. Twice a year all specialists must attend local scientific meetings and someone from each centre must go each year to the parent institute for postgraduate study. Each individual oncologist is expected to do a course of 1 to 3 months at the Herzen Institute at least every 5 years. Here they do practical work as well as attending lectures; in fact a good deal of the surgery seems to be done by oncologists from the periphery under the eye of one of the senior surgeons of the institute.

The heads of departments in these institutes may become extremely

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specialised, dealing only with chemotherapy or with tumours of one organ such as the oesophagus, for example. The feature of these specialist units within these institutes is their abundant supply of clinical material selected for their needs, trained assistants and their own research laboratories, often leading off the same corridor as their wards. Though highly specialised, they work in an institute in contact with other special units and with the fundamental research departments. Some of the special oncological units are in institutes devoted to the study of all diseases affecting the site or system concerned.

Patients and the Service

Every citizen of the Soviet Union has a health card from birth. Up to 16 years of age he attends a paediatric polyclinic. After 16 he gets a new card, is put on the list of a local doctor allocated to him according to his residence, and he attends an adult polyclinic. He may change his doctor if he wishes, but to do so must submit an application in writing. On attending the polyclinic, if suspected of neoplastic disease, he will be referred to the general practitioner in that clinic detailed to be concerned with the oncology service if it is a large clinic, or, if small, he will be sent direct by his doctor to the nearest oncology dispensary.

Many general practitioners do regular postgraduate work in hospitals, and while there are subjected to intensive propaganda which lays great stress on the early diagnosis of cancer and the need of speed in reference to the oncology service. In a polyclinic it is thought much better to send a patient for observation to the oncology service who turns out not to have a tumour than to miss an early carcinoma. As a result over 50 per cent of the patients referred to the oncology dispensaries have no evidence of any neoplastic disorder. The vast task of sorting which results is eased a little by the general practitioner oncologists in the larger polyclinics.

In the large centres of population such as Moscow, all oncology dispensaries and polyclinics report their patients with tumours to the central hospital bed service. The research institutes by contact with this service can draw the clinical material they require for their special units as their own beds become available. While we were there, for example, one institute made contact with the service so as to admit two patients with peripheral tumours suitable for treatment by chemical perfusion.

Propaganda to the lay public about tumours is also intensive. Much of this is done through popular magazines such as *Health*. Posters appear in factories, assembly plants, and hospitals; lectures are given in clubs, and all teachers in schools receive health education which includes oncological instruction and which they are supposed to pass on. Doctors, nurses, and health visitors carry propaganda into the home.

Regular examination as a precautionary measure is advocated, but the result of the propaganda to lay and medical public has produced such pressure on the oncological dispensaries that it seems they are not

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pressing this aspect at present. Even with this influx of patients for examination, however, surveys suggest that, in some areas at least, about 80 per cent of patients with neoplastic disease are seen in the oncological service and registered with them. The official view is that lay propaganda is difficult and forms no more than a useful backing to the much more valuable medical propaganda.

Registration

The attempt to form a comprehensive, nation-wide registration of all neoplastic disease is a bold project of great interest. Its difficulties in a country as large and diverse as the USSR are great. The opportunities it presents for the collection of general morbidity statistics, and for special studies of environmental factors, methods of investigation, the natural history of rare tumours, and the efficacy of therapeutic methods are important.

The Herzen Institute is already conducting a most interesting demographical tumour survey through its scattered dispensaries covering most varied environmental conditions. Areas with a high incidence of primary liver tumours and of upper gastro-intestinal tract tumours, for example, are being studied.

Comment

A comprehensive oncological organisation based on a full-time specialist service, centrally directed, supported by intensive propaganda, regular postgraduate education, and continual emphasis on clinical research carried much of interest. One hears so often in other countries that cancer is not a speciality (a gross over-simplification of a complicated problem with a grain of truth in it), that it is, at least, a change to be in one where this question appears no longer to be even a point for discussion.

The two most impressive aspects to me were, first, the intensive effort to achieve early diagnosis and complete registration, and to use the information gained; second, the attempt to weld together, in one building under clinical direction, extensive research and treatment organisations where discussion flowed freely, and where neither doctors nor scientists had any excuse for not knowing what the others were thinking or doing.

We did not go to be critical but to observe; there were, of course, some aspects of the way in which they work which we would not accept. This did not detract from our interest in much that we found novel, expert, and stimulating. Many of the staff of these institutes spoke English, some extremely well. They were warm in their friendliness, independent in their outlook, delightful companions, and most interesting exponents. Their knowledge of work outside the Soviet Union seemed to be more academic than practical; they have an excellent translation

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service at their disposal but not much opportunity for foreign travel. We enjoyed their company, learned much, felt welcome, and have been able to entertain a few of them in return in this country since then. We should like to see many more. The outcome of this nation-wide experiment in the study and treatment of all patients with tumours is one we shall watch with sympathy and keen interest.

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PSYCHOLOGY

(1) Current Approaches

O. L. Zangwill

IF by psychology is meant the work of Freud and Jung, it may truthfully be said that psychology does not exist in the USSR. Freudian concepts have no place in Soviet psychology and no use whatsoever is made of psycho-analysis or its derivatives in the treatment of mental illness. Even Adler, staunch socialist though he was, is disregarded—perhaps because the Adlerian psychology lays such stress on individual competitiveness. At all events, Freud is totally without appeal to the present generation of Soviet psychologists and no trace of his influence is apparent. It is as though he had never existed.

And yet, of course, the situation is not really so different in the West. Although Freud's ideas had tremendous impact on the climate of Western thought, and have to some extent penetrated into psychiatry—especially in America since the war—academic psychology has been comparatively little affected by the Freudian revolution. As psycho-analysts see it, this is largely due to the conservatism and timidity of the academic mind. Although there may be some truth in this stricture, it is not the whole story. Academic psychologists have a well founded distrust of 'closed' systems of explanation and of theories not obviously open to proof or disproof by the test of experiment. As they see it, modern psychology should evolve as a scientific discipline, experimental in method, and falling within the general framework of the biological sciences. It has little use for unverifiable speculation, no matter how original or dramatic. Although psychologists have the highest admiration for Freud as physician, thinker, and prophet, they have little wish to commit themselves to his ways of thinking or to limit their inquiries to the torrid intimacies of the consulting room.

An academic psychologist who visits the Soviet Union—and I was one exactly a year ago—finds, perhaps surprisingly, very little to surprise him. Soviet psychology, like our own, is experimental, and many contemporary lines of inquiry in the West are strongly represented in the USSR. Indeed, the visiting experimental psychologist may well find himself more at home in a Soviet psychological laboratory than in the psychiatric clinic of his own home town! In Russia, as here, it is believed that psychology should concern itself with the systematic study of behaviour and should make use wherever possible of experimental and statistical methods. The Soviet laboratories are excellently designed for such work; indeed the quality of their equipment is at least as good as ours, possibly even better. Moreover, I was startled to discover how much more the Russian psychologists know about our work than we know about theirs. They not only read our journals but take full account of our work in their own inquiries. We, on the other hand,

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have massively ignored the Soviet contribution to experimental psychology, even where it touches closely on our own interests and preoccupations. It is apparent that what to us is an iron curtain, to our Soviet colleagues is a one-way viewing screen.

AND yet, of course, there are differences. Psychology in the USSR has its own history, its own tendencies, its own peculiarities. These emerge gradually as one gains acquaintance with Soviet psychology and comes to appreciate the intellectual framework within which it has evolved. By this, I do not mean orthodox Marxism—though this has played a part—so much as a variety of attitudes and viewpoints that are intrinsic to the subject itself as it has developed in Russia. Some of these indeed derive from pre-revolutionary sources, others from men such as L. S. Vygotsky, whose work is little known in the West. Again, though Pavlov's work on conditioned reflexes has had great influence on Western psychology, especially in America, its influence on psychology in Russia has been of an altogether different kind. In the West, Pavlov is remembered as the man whose work gave teeth to J. B. Watson's behaviourism, which swept America in the nineteen-twenties, and which in more sophisticated form still largely governs current theories of behaviour. In Russia, on the other hand, there has been no corresponding behaviourist movement. Soviet psychologists, unlike their opposite numbers in the West, do not work with animals, experiment directly on the brain, or advance general theories of behaviour on the basis of the conditioned reflex. In Soviet psychological laboratories there are no rats, not even dogs. Their population is exclusively human.

What is the reason for this difference? It derives, I think, from Pavlov's own distrust of psychology and his strongly expressed disapproval of attempts to erect general theories of behaviour on the basis of his work. In the USSR Pavlov is honoured and respected purely as a physiologist. The large and powerful institutes dedicated to the study of 'higher nervous activities' (broadly, conditioned reflexes) are manned exclusively by physiologists, many of whom echo Pavlov's disdain for psychology. Although I was told that Pavlov, towards the end of his life, seriously considered setting up a psychological laboratory within his Institute at Leningrad, believing that physiology had now advanced sufficiently to keep psychology on the right lines, nothing seems to have come of the idea. At all events, I found no psychologists at work in Institutes of Higher Nervous Activities (with the exception of one or two who have deviated wholly to neuro-physiology). All work on conditioned reflexes and their underlying brain mechanisms is being done by physiologists; psychologists restrict their activities to the study of human behaviour.

And yet, of course, Pavlov has had great influence on Russian psychology. This is expressed in two rather different ways. First, it seems to be agreed that the data of psychology will ultimately find explanation

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in terms of neuro-physiology, by which is meant the Pavlovian 'neuro-dynamics' (a blend of empirical and speculative neuro-physiology). Indeed, a group of psychologists under Professor B. M. Teplov is already attempting to correlate certain properties of temperament with the Pavlovian 'dimensions' of higher nervous activities. (This work has close affinities with that which is being undertaken by Professor H. J. Eysenck and his colleagues at the Maudsley Hospital in London.) Although, as I have said, psychologists in Russia do not work directly on the brain, they appear to have little doubt that much of their work will eventually be translated into the language of physiology.

Secondly, Pavlov made it clear that there are important differences in the physiological mechanisms which govern human as opposed to animal behaviour. 'Pavlov', said Professor A. R. Luria (my host for much of my time in the USSR), 'had no doubt that the laws of conditioning are quite different in man and animals.' As Pavlov saw it, the acquisition of speech—which he called 'the second signal system'— introduces a quite new dimension into higher nervous activities and permits very much more complicated behaviour. Now Soviet psychologists regard it as very much their concern to define precisely the ways in which human and animal behaviour differ and to extend Pavlovian principles to take account of the evolution of language. Indeed, Professor Luria has himself undertaken important studies of the acquisition of speech in children and the ways in which it comes to regulate sensori-motor learning and the acquisition of skill.[1] He has also undertaken important studies of the role of semantic factors in human conditioned reflex activity. Although these studies obviously derive inspiration from Pavlov, they can in no sense be regarded as attempts to 'reduce' human behaviour to the level of conditioned reflexes in dogs. Indeed, no one who knows Professor Luria could possibly accuse him of lack of concern for what is distinctively human in human behaviour.

Russian psychology then is not—repeat not—behaviouristic, as the term is understood in the West. Unlike Anglo-American psychologists, Russian workers are more interested in the differences between human and animal behaviour than in what they have in common. Further, as I have said, there is no interest whatsoever in 'behaviour theory' of the contemporary Western brand. This is of particular interest when it is borne in mind how much recent American behaviour theories, as exemplified by Hull, Spence, and Skinner, owe to the Pavlovian tradition. The reason is, of course, that whereas Anglo-American psychologists study principally rats (or so it might seem on superficial inquiry), psychological work in Russia is wholly restricted to the study of man.

ANOTHER important fact to bear in mind when comparing Russian with Western psychology is the great influence which L. S. Vygotsky

[1] This work is well described in Luria's *The Role of Speech in the Regulation of Normal and Abnormal Behaviour* (Pergamon Press, 1961), based on three lectures delivered in the University of London in October 1958.

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has had on the Russian psychological tradition. Vygotsky was a highly gifted man of most sensitive temperament who died in 1934 at the early age of 38. Although influenced in some degree by Marxist philosophy, Vygotsky appears to have been quite untouched by the Pavlovian spirit and was supremely indifferent to conditioned reflexes. His best known work was on the development of speech in childhood and its relations to conceptual thought.[2] In this, he displayed an approach analogous to —and indeed in some respects inspired by—the earlier work of Jean Piaget, which has had wide influence in the West. Although stressing the social origins of language to a far greater extent than Piaget, Vygotsky had no doubt that thought and speech evolve along different paths and subserve different, if overlapping, psychological functions. In spite of the fact that he did not live long enough to follow his ideas through, there can be no doubt as to his originality or to the influence which he has had on his successors. As Professor Luria puts it: 'All that is good in Russian psychology today comes from Vygotsky'.

Vygotsky's influence is particularly apparent in educational psychology, in which the Soviet Union leads the world. In the West, educational psychology is only too often treated as a subject of doubtful scientific pretensions and relegated to semi-moribund Departments of Education. In the USSR, on the other hand, it is accepted as an integral part of general psychology and attracts some of the best workers in the field. Indeed, the largest section of the State Institute of Psychology in Moscow is devoted to the study of child development and educational problems. Among studies in progress when I made my visit there may be mentioned an experimental analysis of learning capacity in relation to age, with special reference to the ages at which instruction in the different school subjects may be most profitably begun, and a series of investigations on the nature of conceptual attainment, with special reference to science and mathematics. I was interested to learn that experimental schools have been set up in association with the Institute that provide opportunity for controlled, though essentially realistic, experiments on the efficacy of different teaching methods. It would seem that educational research in this country has much to learn from Soviet enterprise.[3]

Intelligence testing, however, is poorly regarded in the USSR and little, if any, use made of standardised tests of the kind which, until recently at least, have been so popular here. Although this neglect of individual differences in intelligence has ideological roots, it is important to bear in mind that we still know little for certain as to their origin. Although commonly assumed to reflect differences in innate endowment, it is entirely possible that intelligence depends to a considerable degree

[2] An English version of L. S. Vygotsky's *Thought and Language*, edited and translated by Eugenia Hanfmann and Gertrude Vakar, was published in 1962 by the M.I.T. Press.

[3] Some account of contemporary Russian studies in educational psychology is given in *Educational Psychology in the Soviet Union*, edited by Brian and Joan Simon, London, 1963.

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on environmental factors, especially in early childhood. In any case, psychologists in the USSR believe that intellectual abilities almost certainly owe more to environment that to heredity, and consider it of the utmost importance to study the ways in which they may be sharpened by instruction. (Where such instruction is found to be fruitless, as in the case of the severely subnormal, it is interesting to note that a defect in brain function is invariably assumed.) Although these ideas may seem heretical in the West, it cannot be said that they are wholly lacking in scientific foundation.

I would now like to turn briefly to some more technical aspects of experimental psychology. In recent years, ideas derived from modern communications and control engineering (cybernetics) have insinuated themselves with remarkable rapidity into psychological thought and may be said to have transformed large areas of the subject, especially those concerned with human sensori-motor reaction, decision, and choice. Information theory, originally designed to provide a measure of the information transmitted through man-made communication channels, has found important application to the study of human capacity. Whereas twenty years ago bright young men in experimental psychology were deriving their main inspiration from physiology, today information theory is all the rage. Now exactly the same thing has happened in the USSR. There, too, information theory has commended itself widely to psychologists and is being applied to human problems with a zeal which matches, perhaps even exceeds, our own. It is, indeed, in this highly contemporary field of 'human engineering' that British and Soviet psychologists share the maximum of common ground.

One or two examples of this new concern may be cited. In the University of Moscow, a unit concerned with 'programmed learning' has been set up under the joint auspices of the Departments of Psychology and Probability Theory. Its interest is by no means limited to 'teaching machines' but embraces the whole field of information theory in its application to psychology. This field has also attracted the interest of Professor A. N. Leontiev, one of Russia's outstanding psychologists who has contributed widely to the growth of the subject in all its aspects. In Leningrad, a unit under Dr. B. Lomov is concerned with the coding and processing of information in visual perception. Physiologists, too, in particular Dr. G. V. Gersuni and Dr. V. D. Glaser of Leningrad, are becoming interested in the application of information theory to sensory processes. Indeed, it should be said with some urgency that no student of human behaviour envisaged from the standpoint of information theory can afford to neglect current Soviet work.

I saw little of psychiatry in the USSR but enough to appreciate that it is regarded essentially as a branch of neurology. The idea that certain kinds of mental illness are 'psychogenic', i.e. solely the product of emotional conflict or related forms of psychological maladjustment, is given little credence; its basis is sought rather in constitutional or

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acquired physical disorder. Psychotherapy is equated with re-education and approached from the Pavlovian standpoint. Although the Pavlovian interpretation of mental illness has found few exponents in the West, there can be no doubt that our psychiatrists, too, are becoming increasingly concerned with the somatic basis of mental disorder and its treatment by physical methods. The main difference, however, is that Western psychiatry continues to attach importance to aspects of mental illness that reflect psychological maladjustment and as yet elude convincing translation into the language of physiology.

What about applied psychology? In a communist society, so we are told, science is geared to social needs: the distinction between 'pure' and 'applied' science ceases to exist. This may be so, but in so far as psychology is concerned I found no lack of concern with fundamental issues. Indeed, much of the work I saw, in both psychological departments and Institutes of Higher Nervous Activities, had, so far as I could ascertain, no foreseeable practical application whatsoever. Further, research workers appear to enjoy at least as much freedom in their choice of research topics as exists in this country, and the esteem in which they are held appears to depend wholly on the scientific merits of their work. Although social applications of science are certainly well to the fore, the spirit of scientific inquiry, in and for itself, is everywhere in evidence.

But this does not, of course, mean that applied psychology lacks encouragement. In both education and industry, and to a certain extent in medicine, psychological work is geared to practical needs and its results are freely applied. Nonetheless, I had the impression that there is less stress on applied psychology than is the case in this country, at all events since the war. Psychologists appear to feel less constrained to justify their activities in terms of direct social application and to have less fear of being stigmatised as 'academic'. This perhaps reflects greater intellectual security.

IS it possible to define a 'pattern' of Soviet psychology? This is difficult, perhaps impossible. In Russia, as elsewhere, psychology is far from united and lacks the cohesion ordinarily expected of a scientific discipline. However, the following, admittedly slight, impressions may be of interest.

(1) Soviet psychology regards itself as wholly concerned with the explanation, and ultimately the control, of human behaviour. Psychologists in the USSR do not work with animals or concern themselves directly with the study of the brain as the instrument of behaviour (this is regarded as the province of the neuro-physiologist). At the same time, it is widely accepted that the data of psychological inquiry will ultimately find explanation in terms of the physiology of the brain (Pavlovian 'neurodynamics').

(2) Soviet psychology is not behaviouristic. It acknowledges the distinctive features of human consciousness, placing special emphasis on

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the evolution of language and the socio-historical framework of human activity. It has little use for contemporary American ' behaviour theory ', in spite of the fact that much of it traces its ultimate parentage to Pavlov.

(3) All Soviet psychology is experimental psychology. As in the West, ideas derived from communications and control engineering (cybernetics) are finding increasing application to psychological research. Information theory is being widely used in the measurement of human capacities and in the analysis of human skill.

(4) Psychological disorder is approached along somatic lines and interpreted for the most part in Pavlovian terms. Psycho-analysis and its derivatives are totally disregarded.

(5) Whereas psychology finds appreciable application to practical problems, there is no disregard of fundamental issues. Simple-minded scientific curiosity is as much in evidence in the USSR as anywhere else in the world.

Does all this add up to a ' pattern '? Probably not. But it should be borne in mind that in no country has psychology achieved the status of a unified science. Many psychologists today believe that it is better to study such limited aspects of behaviour as are open to experimental analysis than to seek a set of laws, applicable to the whole realm of mind, much as the laws of physics have found application to the whole realm of matter. In consequence, psychology today has a distinctly piecemeal character, deriving its methods and ideas to a considerable extent from the more highly developed sciences. But whereas, in the West, the tendency has been to approach human behaviour through the study of simpler organisms, to seek the explanation of learning, for example, through study of the behaviour of rats or even flatworms, in Russia it is felt that such study belongs wholly to biology. The psychologist, it is maintained, should concentrate exclusively on the special problems created by man's evolutionary development. As envisaged in Soviet Russia psychology faces squarely the problems of human consciousness, human intelligence, and human language. Pavlov has merely issued the directive: it is up to the psychologist to finish the job.

(2) Trends and Schools

Neil O'Connor

BEFORE the last war and during it, the subject matter of Soviet psychology was virtually unknown to English readers, with the exception of a few of Pavlov's works translated by Anrep (1927) and Horsley Gantt (1928; 1941). Apart from the work of this outstanding physiologist and some fragments such as an article by Vygotskii (1939), little filtered through. By the end of the war the average English psychologist might know something of the above works and might in addition have seen a book of Luria's (1932) in English, and might have

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heard of the 1936 Decree concerning Pedology in Soviet schools. This state of affairs was due partly to lack of available material, and partly to lack of interest. During this time nonetheless, Soviet psychology, like English psychology, was painfully establishing itself against a background of philosophy and physiology. A brief outline of this early period is our first concern.

The beginning of Soviet psychology was eclectic, with several conflicting schools derived in part from similar schools abroad. However, within a short period it began to attempt to define its own psychology. During this time, as in any other country, the traditions of Russian thought and previous experiment remained predominant. Thus in 1863 Sechenov with his *Reflexes of the Brain* had laid the ground for Pavlov's study of conditioning, and early in the 1920s a discussion arose centring on the artificiality of studies done on one dog seen in isolation, as Pavlov's work required. Blonskii and others criticised the artificiality of reflexology, as it was called, whereas Kornilov and Bekhterev developed a modified form of it called 'collective reflexology' to meet such criticisms. In doing so Kornilov introduced 'Reactology', a form of Behaviourism similar to that of Watson in the United States.

Both of these views were attacked for ignoring the role of consciousness by Vygotskii and others in the 1920s and 1930s; Behaviourism was similarly condemned. At this time Vygotskii's views on child development, which later influenced Luria and much recent Soviet work, did not appeal extensively in his own country. This is surprising in view of the force of Lenin's views and their wide acceptance. At this time the publication of Lenin's philosophical notebooks established a Marxist view of thinking and of psychology in general in the Soviet Union. These principles were a statement of belief for all dialectical materialists. They assumed the primacy of matter, the reflection of reality in the mind, i.e. the reflection of matter in consciousness. The brain is the organ of thought and no thought takes place without it. Mind no less than matter is affected by radical changes. Change in man is brought about not so much through evolution as through history and the dissemination of ideas. Man is changed through his environment and to study learning we must therefore look at the practical process of learning in schools. Finally, the new way of thinking discredited earlier modes of thought as characteristic of the outmoded capitalist society. Therefore, for example, selection in schools by psychological means, practised in Soviet schools until the 1936 Decree, was regarded with suspicion. It was seen to be an unsuccessful and unprofitable way of helping the backward, and was rejected for Soviet schools at about the same time as it was gaining currency in England. We here have since taken the Soviet road of regarding it with suspicion.

IT is interesting that the influence of Pavlov should have been so widespread for so long after his death. His work had a profound effect on Russian psychology and physiology during his lifetime, and this

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continued even as late as 1950, thirteen years after his death. There is little doubt that the discussions referred to earlier were to some extent overshadowed by the influence of Pavlov, otherwise it seems very likely that psychology in the Soviet Union would have taken a slightly more social and a slightly less physiological path than proved to be the case. It is in fact somewhat surprising, in view of the emphasis placed by Lenin on the importance of the social milieu in the determination of man's consciousness, to find that sociology as a discipline did not exist in the RSFSR until about three years ago.

The continued popularity of Pavlov's ideas can be explained in large part by the influence of his successor Ivanov-Smolensky, who continued work on the conditioned reflex in Leningrad. His idea of verbal conditioning in human beings and the extension of conditioning to the treatment of mental illness was widely popular in the post-war period. The fact that it ceased to be extensively studied in the late forties and early fifties indicates the expansion of Soviet psychological work at this time; but it also shows that part of the prestige of this kind of work was artificially perpetuated despite the willingness of other psychologists to turn their attention to a broader field of psychological problems. If we except the period of the war, the years from 1936 to 1942 and again from 1945 to 1950 were years of ideological conflict in psychology, sharper it would seem to an outside observer than either the previous or the following period. Especially from 1945 to 1950, somewhat one-sided controversies over idealism and materialism and the demand for partisanship became more and more intense.

Leading scientific workers, such as Rubinstein and Leontiev were involved, and their published work criticised, not always because it was considered to be philosophically incorrect, but sometimes for lack of adequate emphasis. This was the period of official support for Lysenko and the period also of the domination of Zhdanov, the leader of Soviet orthodoxy on scientific and cultural issues.

Since that time a number of changes have occurred which leave the direction and content of scientific work a good deal more in the hands of experts, rather than in the hands of philosophers of Marxism. The practical application of research findings is naturally a matter for administration and politics, but, except in rare instances, the pursuit of pure science is left largely in the hands of those who have impressed their colleagues with their ability, rather than in the hands of skilled dialectical materialists without expert knowledge in the field.

Concomitantly with this change, Pavlov's influence both in psychiatry and in psychology declined. There is no question, of course, of attacking the greatness of this initiator of research, who certainly laid the foundation of psychological learning theory whether in the USSR or the USA. Rather the scope of the subject has been extended to include just those studies of behaviour which might have been thought improper by Russian psychologists trying to develop a Marxist psychology in the 1930s. The extent and importance of this change, at least in terms of publications,

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can be gauged by examining a recent issue of a Soviet psychological journal, to see what kind of subject matter is treated and in what way.

THE publication of *Voprosy Psikhologii* (Problems of Psychology) was suspended during the war, and not started again until 1950. It is the only journal which treats psychology as a separate subject, distinct from educational psychology or physiology. A collection of articles translated from this journal covering the period from 1950 to 1960 was published in 1961 (edited by the present writer). The selection was made in the first instance by Russian colleagues, and the final selection from their list was made by the editor. This volume shows considerable variety in both subject matter and treatment, as would any similar selection, but there is little material of a semi-philosophical nature; articles of this kind had to be excluded. If a similar collection were made today this would not be necessary; in the four most recently available copies of *Problems of Psychology*, some 52 articles were published, of which only three could be considered to be at all ideological or political; one was a statement concerning the tasks of psychology following the June plenum of the central committee of the CPSU. This was only four pages long. Such a small percentage of philosophical articles would have been unimaginable even as little as ten years ago.

Taking two numbers of *Voprosy Psikhologii* for 1963, we find that the articles covered the following subjects: an experimental study of the development of personality in children, a study of the types of nervous systems in children, an investigation of the phenomenon of the 'perception' of print by touch, an experiment concerned with the ease of discrimination of articles of different degrees of complexity against a complex background, a mathematical-statistical article concerned with information theory and data-processing, and several articles of lesser interest. In two of these articles there were references to English or American authors (in one case eighteen of them), half of which were in the English language. There was also an extensive list of books received in Moscow from foreign sources, about 225 in all. It was divided into subsections on philosophy, psychology, physiological psychology, psychological method, learning and communication theory, emotion, motivation, personality theory, social and anthropological psychology, developmental psychology, educational, industrial and comparative or animal psychology, and the psychology of individual differences. Again, about half of the books listed were in English.

In another number of the journal we find similar articles. There is a study of nervous types or rather types of nervous system, and another on the process of recognition. One investigation studied the effect of types of nervous system on the galvanic skin response, i.e. the electrical conductivity of the skin. Three articles were concerned with children's learning in different subjects, and another discussed the time-honoured psychological problems of weight illusions. Articles on the conditioned reflex, the development of the sense of pitch, and the problem of fatigue

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completed this particular issue. Frequently there are additional short discussions of some interest; these deal with such questions as social psychology and subliminal perception, and experimental method. Using these investigations as background, the reader can get some idea of the schools of thought in the study of psychology in the USSR today, of their origins and the personalities involved in each particular area.

Judging from the number of articles dealing with the question, types of nervous system is one of the major preoccupations of Soviet psychologists. In point of fact this problem stems from the work of Pavlov, who first noticed different degrees of excitability in dogs. At his suggestion Ivanov-Smolenskii extended this work to human beings, but it was Teplov, much less well known to English readers who are not themselves psychologists, who studied the field thoroughly and may indeed be said to have created it. Teplov and his colleague Nebilitsyn have not published extensively in English but their work is well known and respected in Moscow. In essence these studies of types of nervous system have as their major aim the determination of the reactive qualities of people who may be supposed to differ in their types of nervous system. For example, a person may be supposed to have a strong or a weak nervous system, or one which is flexible or inflexible. If a person has a strong nervous system then his threshold of response to a particular stimulus is likely to be high—in loose terms, he will not be easily aroused. A person with a weak type of nervous system will react more readily and will reach a level of intensity-tolerance (beyond which a stimulus of increasing intensity will seem painful) at a somewhat lower level of intensity than the person with a strong nervous system. These qualities and others determine the way in which a person can learn most readily; students with different qualities may need to adopt different patterns of study.

How is the strength of the nervous system determined? This is done in a number of ways; one method used is to determine the threshold of a particular person to, for example, a dim light. A new stimulus such as a noise can then be introduced and the threshold determined again. A small change indicates a strong nervous system, resistant to stimuli, and a large change in threshold indicates a weak nervous system, or one which is subject to disturbance. More reliably, the patient's condition can be changed through the use of drugs rather than by the introduction of a disturbing stimulus such as a noise. The most commonly favoured drug in these studies is caffeine. In such a short article it is not possible to give a better idea of this interesting work; some comprehensive articles in English by Teplov are listed at the end of this article.

ANOTHER extensive group of experimental studies has been inspired by Luria, who, because of his visits to England, his excellent English, and his lively personality, is probably better known than any other Soviet psychologist. Luria's first report of experimental work was published in 1932. It covered studies of students, criminals, and

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imbeciles made in the early years of the revolution. Since the war he has published a great many works on mental subnormality, some of which have been translated into English. A list of his recent work is given below. Luria was greatly influenced by his one-time colleague Vygotskii, who died about thirty years ago, at an early age. He has been concerned with the problem of the relationship between the first and second signalling systems, i.e. between percepts and heard speech. The difference between signs and words is regarded by psychologists of this school as being of vital importance. The stages of development in children have been extensively studied in these terms, as have also the pathological defects of development in the severely subnormal. In Luria's view children must learn to express their own thoughts in words which originally derive from the instructions of others. These 'external' words must be internalised in the child's own overt speech and then in his own inner speech before they can become his own thoughts. Through this process of internalisation, children learn to control their own motor movements and to initiate activity. Luria's work along these lines is taken further by Zaporozhets, while the effects of lack of development on the connection between the primary and secondary signalling systems have been studied by both Vinogradova and Lubovsky.

Luria has worked both in this field and in the field of neuro-surgery, where his wartime experience gave him the opportunity of developing some interesting theories concerning different types of aphasia. He has developed a most promising although as yet unproven idea concerning the localisation of the capacity to differentiate quanta in time, as distinct from space. Luria, now in his late sixties, regards himself as one of the older generation, but his energy and inventiveness continue to earn him a place in the forefront of psychological research in his own or any other country.

The psychological studies with which the present writer is most familiar—apart from that already mentioned—are the work of Leontiev, Sokolov, Ananiev and his colleagues Vekker and Lomov, and Anokhin—although Anokhin's is sometimes closer to physiology than psychology. In the field of educational psychology the outstanding workers would appear to be Zaporozhets, Elkonin, Milerian, Zinchenko, Bogoyavlenski, and Menchinskaya. Of course, the work of Leontiev on learning theory has its direct application in educational practice, but is also notable in itself. One special group of workers deserves particular notice because it stands somewhat aside from the mainstream of Russian work and often deals with entirely different subject matter. This is the school of Uznadze in Tbilisi in Georgia. Uznadze has suggested that words act as vehicles of communication and are so used by children before these words have a conceptual meaning. The school's current leader is Natadze, a Georgian and French-speaking psychologist, who, like Leontiev, has spent some time training in Paris. The work of Leontiev, Sokolov, and Ananiev and his colleagues also deserves special mention.

Judging from Leontiev's published work, his inclination is towards

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theoretical rather than experimental studies. He has been responsible for developing the idea of relatively equal skills based on different and often unequal abilities. He has in fact addressed himself to the problem of individual differences in ability which often troubles Western psychologists and which has been responsible for the development of the idea of inherent and unalterable mental qualities. Leontiev does not agree with this idea. In an article entitled 'On the formation of abilities', and in another called 'Learning as a problem in psychology' published in 1950 and 1957 respectively, he began to analyse the learning process from its foundation. He describes the essence of the learning process as the growth of a connection between two events in such a way that one comes to represent or signal or 'mean' the other. This is the foundation of the orienting reflex and the beginning also of conditioning. After making a number of observations about the generalised and contracted nature of long-term learning, Leontiev deals directly with the question of individual differences. I have summarised what he says in a chapter on Soviet educational psychology. 'Abilities—even innate ones—says Leontiev, are dependent on external conditions as well as on dispositions. . . . Leontiev illustrates this by referring to the speed with which trained animals solve laboratory problems in comparison with animals which have not had this experience. It is implied that training can reorganise the pattern of individual differences found in any sample of people. Even the fundamental nervous type can be changed by a particular regime of experience. Thus even basic abilities have environmental as well as constitutional origins. . . . This is the suggestion that any one human skill may have as its base a number of combinations of basic dispositions. Woodrow (1946) in a long series of studies has shown that this is inevitably true over a long series of tests of one task. As skill increases new abilities come in and some others drop out. However, Leontiev here suggests that an individual may succeed at, say, algebra with one set of capacities, and have as his equal someone whose skill is based on quite other capacities in a different combination but in the same subject.' This statement of a Soviet view of individual differences and individual similarities comes close to being a theoretically plausible groundwork for Soviet notions of relative psychological equality. No other theory of equivalent status is known to me. Leontiev must be seen therefore as one of the leading figures in Soviet psychology; he undoubtedly comes closest to being a spokesman for a socialist ideology in psychology.

The main work of Sokolov, who is one of the leading psychologists of the younger generation, has been on reflexes, and of these he has made the orienting reflex his speciality. It is still too early to estimate the full importance of Sokolov's work, because up to now he has experimented along a number of lines, including the development of an information theory approach to learning problems. His major work on perception and conditioned reflexes, published in Russia some years ago, has now appeared in English, and readers will be able to form their own

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impressions. No one questions the quality of this work, which takes intelligent account of a great deal of Western physiological work. It advances a suggestion of Pavlov's a good deal further and takes the experimental work well beyond anything so far attempted elsewhere. As with a great deal of Soviet work, there is a lack of statistical sophistication in Sokolov's work, but it is likely from the procedures which he adopts that even if statistics were applied the results would be found to hold up. His emphasis is on the function of certain extinguishable reflexes which mark the first response of any animal or man to new and especially to new and intense stimuli. He has noted that the animal turns towards such stimuli and pays attention to them, often suspending all other activity. After a few unrewarded exposures of the stimulus the individual will either respond to the stimulus or lose interest in it. Sokolov has noted this behavioural phenomenon and also described the physiological concomitants of the orienting response in great detail. His analysis of central and peripheral blood flow and the connection of blood flow and autonomic response is of great interest.

Ananiev, Vekker, and Lomov in Leningrad have done extensive work on the sense of touch and the relationship between right hand and left hand in the development of knowledge of objects among the blind. This work, which has been going on for some time, has recently been extended by Lomov into industrial or engineering psychology. The function of the left hand in holding and the right hand in exploring objects in right-handed people, suggests the possibility of examining different perceptual functions for the two hands and presumably also for their areas of localisation in the cortex. The work of Anokhin, an able physiologist and director of the Sechenov laboratory, is less oriented towards psychology than towards physiology.

There is no space here to deal with the work being done in educational psychology and the study of severe subnormality, not to mention Smirnov's extensive studies on memory. In the field of child study and development Zaporozhets is outstanding. He is concerned with problems similar to those studied by Luria. He is interested in the function of different organs at different stages of a child's growth, especially in the way in which language is related to motor movement and also in the relationship between eye-movements and growth. Zaporozhets and his colleagues are aware of the way in which orientation and manipulation of the environment can alter the signal properties of an object of display. For example, they try to specify the manner in which turning the head and eyes affects the sound level of sound stimuli or the intensity of light stimuli. Levitskaya and Neverovich, working with Zaporozhets, have shown how experience in one modality can materially alter the threshold for stimulus in another. Thus pitch discrimination can be greatly changed if parallel visual representation is made of each note. One experience of this kind is enough to transform the sensitivity to pitch alone. Simkina and Zaporozhets have also studied visuo-motor coordination to determine how far the eye plays a leading role. Their conclusion is that the eye

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is at first dominant, but that in later years learning perception depends on smaller movements of the eyes. This refers of course to children between 3 and 7 years of age; below the age of three, kinesthetic stimuli play an important part in exploration.

BRIEF as this account has been, it is enough to show how extensive and diverse psychological studies are in the USSR. Can anything be said then about trends and influences in this very wide subject? It is perhaps not too difficult to trace two or three basic influences at work, and to make some general comparative observations about this psychology and that of, say, the United States. Pavlov, Vygotskii, and Uznadze, the three fathers of Soviet psychology, would appear to owe little to foreign psychologists except perhaps Piaget. Although these three men represent different schools of thought and different trends in Soviet psychology, there can be no doubt that the greatest influence on Soviet psychologists is still Pavlov. This appears not only in the subject matter studied but in the whole orientation of their work. In the USA, and even in England, there is a strong tendency to think methodologically in terms of the ' black box ', the hypothetical way of referring to whatever physiological mechanism lies behind and beyond the behaviour studied by the psychologist. In the USSR such a point of view is impossible. Never far from the mind of any Russian psychologist is the question of how exactly the animal he is studying is constructed. Socalled molar studies favoured by Hull, in America, are seldom seen as their own justification. Pavlov's influence is also seen in the subjects of study, most of which were either begun or suggested by him. Like no other, he cast his mantle not only over his own day but even thirty years after his death.

As to the weaknesses of Soviet psychology, perhaps the most notable is that lack of statistical rigour mentioned earlier. This may make some ultimate difference to Russian findings, but it is unlikely that it could make much difference to their basic contribution. Is there any reason to suppose that the fact that Soviet psychology draws on its own past for inspiration is a sign of insularity? I think not; it appears that nearly all countries demonstrate this insularity in a great number of respects. Examples which are highly relevant are the way in which such notable English psychologists as Burt were ignored in the USA in their heyday. The long career of Piaget and his great brilliance have eventually insured his recognition outside France and Switzerland, but only after 40 years of continuous work. It seems in fact that in psychology a prophet has no honour outside his own country, unless he takes the precaution of living to be a hundred. For some reason this does not apply to the work of the Americans. In England at least we are familiar with the work of many American psychologists, but even they have far less influence in Europe than they have at home. Hull's methods and terminology, for example, are the stock in trade of a great number of

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Americans, but few well trained English psychologists can make free with his techniques, unless they have spent time at Harvard.

Soviet psychology, then, is individual; it is of three major schools, those of Pavlov, Vygotskii, and Uznadze. It is also a physiologically oriented psychology with virtually no social orientation whatever. In this respect it is very different from psychology in Western capitalist countries, and this in itself is a very strange phenomenon considering the emphasis placed by Lenin and many other Soviet thinkers and philosophers on the importance of society as a generator of man's consciousness. Other superficial differences can easily be detected, such as the lack of emphasis on personnel psychology and the lack of interest in statistics, though these are likely to disappear shortly. Social psychology may itself also be ready to emerge in the Soviet Union as sociology has in Poland, but it will no doubt differ in a number of ways from the social psychology we know here. Such a social psychology, when it emerges, will probably resemble Soviet educational psychology which is oriented in a fundamentally different manner from educational psychology in England; for, as in education, the aims of the two societies are somewhat different and therefore their applied psychologies will be different. In the Soviet Union the chief aim of educational psychology is to promote better education; here it has tended to concentrate on selection. It is possible that in social psychology similar collective trends as opposed to individualist ones will reveal themselves.

Whatever else might be said about Soviet psychology, it is clear that it is an extensive body of knowledge of a scientific kind. It is comparable to American psychology in its expertise and although somewhat smaller in volume is growing rapidly and already equals any other psychology in quality.

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KEEPING THE SCIENTIST INFORMED

Cyril W. Cleverdon

ONE cannot discuss the position in the Soviet Union in relation to scientific and technical information without relating it to the problems which all countries have to face. In most fields before the last world war, a senior scientist in any country would probably be aware of all the other organisations throughout the world which were working on similar subjects. He might possibly know personally the senior scientists in such organisations, but at any rate he would expect to read the papers in his special subject and also, by means of abstract journals, be aware of work that was being done over a much wider field.

The past twenty years have brought about a complete change in this position, due to the vastly increased sums of money which have been made available for research and development. Every research grant must normally end with the production of a report, and this in itself has created problems for primary publication. The learned societies have been overwhelmed with papers, and have been unable to cope with the amount of material offered for publication. Many societies have imposed drastic restrictions on the length of papers, and for some years it has been common practice for societies to make page charges for publication. Even in the field of documentation, for a ten-page article in the appropriate American journal, the author would have to pay 300 dollars for the privilege of having it published. These restrictions, however, only divert the flood, so there has been a proliferation of new journals and a large increase, in certain fields in particular, in the number of research reports issued by the organisation undertaking the research.

This, in turn, has had its effect on the secondary publications, namely abstract journals. These have had to be increased in size, and have thus been drawn into the vicious circle that increasing costs tend to reduce sales, so that most such publications now need heavy subsidies to keep going.

At the next stage, that of the individual scientist or engineer, this situation has a three-fold effect. So much research work is being done, so many different organisations are active, that it becomes increasingly difficult to keep abreast of the literature dealing with his own immediate activities. If English is his native tongue, he will find that a growing number of the pertinent papers are written in a language he cannot read. Finally, when he undertakes a new project, or comes up against a new problem, he often lacks the background knowledge which enables him to locate the necessary information, due to his inability to read anything outside his immediate interest.

Ultimately all these factors react on the library. The cost of books and journals and the space needed for their storage create problems which

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can have the result of increasing demand on inter-library lending. More particularly, however, the clientele of the library make increasing demands on its services, as individuals because they have less knowledge of sources, and collectively because there are many more scientists and engineers. So the library can no longer play the relatively passive role of collecting and storing material, but must develop into a dynamic organisation and actively assist the research worker in his quest for relevant information.

WHILE all countries are faced with these problems, it is in the United States and the Soviet Union that the most energetic action has been taken to meet them. Both countries are alike in their approach to research in documentation, and in this respect they are both striving towards the goal of complete mechanisation by the use of computers. It is in the overall organisation of information services in which they differ. America, as an advanced country, has had for many years a complex of information services that have been serving many specialised needs, so in that country the main effort has been the expansion and co-ordination of existing services. In the Soviet Union, apart from a few major libraries, there were fewer specialised information services, and a more radical approach was adopted.

The main organisations concerned with scientific and technical information are the USSR State Committee for the Co-ordination of Scientific Research (GKKNIR), the USSR Council of the National Economy (USSR Sovnarkhoz), the Academy of Sciences, and the All-Union Institute for Scientific and Technical Information (VINITI). The Co-ordination Committee is responsible through the Supreme Economic Council to the Council of Ministers, and amongst other activities it co-ordinates and controls research and the flow of technical information, in particular in relation to industry. With a staff of 30, the headquarters information department lays down the broad strategy in the form of instructions and regulations. It is advised by a Scientific Council on Information Problems, under the chairmanship of Professor A. I. Mikhailov, the director of VINITI. Members of the Council include leading scientists from research institutes or industry and also members of the Academy of Sciences, which is thus closely associated with the Co-ordination Committee in policy-making. The Committee collaborates in this task also with the ministries and with the other state committees responsible to the Supreme Economic Council, especially the State Planning Committee (GOSPLAN) and the All-Union Sovnarkhoz. The problem of co-ordination and the scale of the effort can be gathered from an article by N. Arutyunov, which refers to the existence of 84 All-Union and central branch information bodies, 94 central bureaux of technical information for the regional economic councils (Sovnarkhozy), more than 4,000 technical information bureaux and 3,000 technical design departments at industrial concerns, and more than 16,000 technical libraries. The Committee has issued regulations for the establishment

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The Scientific Information Services

AMONGST THE VISITS ARRANGED for a group of F.B.I. (Federation of British Industries) Research Directors when they visited Russia in October 1963 was one to the Institute of Scientific and Technical Information in Moscow, where we met Mr. Polushkin, a Deputy Director. Like so many Russian scientists in key posts, Mr. Polushkin is still relatively young—in his early forties one would guess. He spoke of the achievements of the Institute with an understandable pride but there was little doubt that his real interest lay in the theory and development of information work. Certainly, as the account of our conversation with him shows, the Russians are working on some methods which have exciting possibilities.

All the literature, from 102 countries and in 65 languages, passes first to the preliminary department where linguists and experts in particular fields sort it into subjects. After this rough classification, photographic copies are made and the classified literature is passed to the specialist departments where the papers considered to be worthy of abstracting are selected. It is recognised that this is the key process and experts with long experience in the field of study are employed to carry out this screening. At this stage bibliographic cards are prepared and complete bibliographies are available just two weeks after receipt of the original paper. At this stage, too, condensed technical translations are produced. The final abstracts are prepared by 20,000 extra-mural consultant experts who may be anywhere in the country or abroad. The Institute attaches great importance to this system: first, the expert in the field concerned is entrusted with the abstracting and so may be relied upon to pick out the really important aspects of the paper; secondly, the expert is the first to be informed of new developments in his field and has them brought to his notice. Great attention is paid to producing the final journal of abstracts quickly. In 1954 publication of the final abstract took place 14 months after receipt of the original paper; now this time has been reduced to five months; making use of improved technology it is confidently expected to reduce the period to some three or four months.

We asked how liaison was maintained between the selectors of the literature to be abstracted and the abstractors themselves. We were told that some of the outside scientists were members of the editorial board and that contact is maintained by rotation of membership. We also asked how duplication of abstracting was avoided when frequently the same work was published in a number of different journals. The answer was that, so far as possible, the same expert receives the different publications. We also wanted to know how growing subjects were subdivided. As an illustration of what happens, Mr. Polushkin told us that up to 1964 works on biophysics were published in the physics *and* biology sections of the journal; from 1964 biophysics would be recognised as a branch of science in its own right.

It was in the fields concerned with the theory, practice, and technology of information work that Mr. Polushkin was most interesting. Clearly of great and growing interest is the application of computer techniques in information work. As an illustration, the newer systems of writing the structural formulae of organic chemical compounds lend

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themselves admirably to computerisation. Programming of a computer could lead to the accurate description of the properties of the substance from its structural formula. As freely translated by our excellent interpreter, 'You feed the structures into the machine and the machine answers questions on characteristics'. Similarly, the machine could be arranged to predict the structural formulae of substances having the characteristics as fed into the machine.

Mr. Polushkin was most enthusiastic in describing the future development of information services as he saw it. He foresaw some drastic changes being necessary if scientists were to be able to keep abreast of the vast amount of literature published. Other, more convenient, methods of presenting their findings must be developed. The writing of scientific papers must be systematised. In the case of abstracts, where no question of authorship was involved, the problems were relatively simple, as the phraseology could be varied to suit the needs of data processing without upsetting the original author. With original papers the problems were more difficult. Beginning in 1964, however, they were going to experiment on a wider scale with the use of 'key phrases' as a beginning. It should be possible to build up gradually a 'vocabulary' of key phrases so that ultimately a scientific paper could be compiled entirely from such phrases. It was conceded that it might be difficult to persuade scientists to write like this but we agreed that an intelligent editor could paraphrase or transcribe a paper into well chosen key phrases. An obvious extension of the idea is to develop an internationally agreed collection of key phrases each with an agreed presentation in different languages and with a *numerical* key. (Mercifully the Russians employ Arabic numerals.) Here, then, would be a truly international language. All scientific papers, written in any language, could then be reduced to a series of numerals representing the key phrases used. After feeding into the computer, press the knob marked 'English', 'Sanskrit', or what you will, and the machine will produce the paper in the language required. One can already hear the howls of protest from the purists—but surely rather this than the turgid prose that so often emanates from scientific writers.

Is the whole project a pipe-dream? Surely not. After all, we already use numerical codes for cables to wish people a Happy New Year and so on, and, with the growth of international air travel, a whole series of acceptable international symbols has been evolved. To look on doors for the silhouette of a lady or gentleman, we all know, saves us from having to ask embarrassing questions, but can a system of key phrases be evolved capable of conveying sufficiently differing shades of meaning? Again, surely, the answer is 'yes', and the use of a suitable decimal system should enable such phrases to be readily codified. Certainly, ambiguities arising from mistranslations would be avoided. It has been said that the only way known to man of arranging letters in a completely unambiguous manner is in an algebraic equation. Surely the developments outlined by Mr. Polushkin would provide a way out, at least for scientific literature, where precision of meaning is all-important.

D. H. Sharp

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and activities of technical information departments at industrial plants and applied research institutes. Such regulations are obligatory, even though the detailed organisation is determined locally.

On the technological side, great importance is attached to the flow of information in all directions; from the research institutes and national information services to the industrial organisations and also in reverse, in relation to innovations or new techniques which originate within the industrial plants. Although it may well be that the machinery for doing this is not yet working at maximum efficiency, it is this aspect of the organisation of information which potentially could be of major importance in achieving increased production. The Sovnarkhozy, which are responsible for this activity, will have on their information department staff specialists for all the main industries, and these individuals are to be responsible for ensuring that new developments are brought to the notice of all the industrial organisations in the area which might benefit from the information. The Sovnarkhozy use their information channels to exchange production experience among different firms, and to bring the experience of the better firms into the less advanced undertakings. This is done through the medium of printed pamphlets and the techniques of mass propaganda (exhibitions, films, models, etc.). They are also concerned with presenting political arguments for increasing automation and reducing manual work and preparing symposia on such themes. Another important part of their work is to send lists of technical suggestions to the firms in their regions and for the firms to report back to the Sovnarkhozy as to whether these suggestions will be applied or not. On receiving a Sovnarkhoz list of suggestions, a firm can write to another firm, referring to the fact that the Sovnarkhoz list states that this other firm has employed a certain method, and the first firm can demand full particulars and drawings so as to instal the method in their own plant. This, in theory, is how the system should work. (A pre-requisite of this system is, of course, a complete lack of private enterprise and competition.) But of course not all Sovnarkhozy are equally efficient, and practice often falls short of theory. In some cases it appears that the information services within particular plants are operating at a more advanced scientific or technical level than the Sovnarkhoz itself, and that an exchange of information and operating experience is taking place between plants without its assistance. However, as an organisation for ensuring that technical information reaches all industrial plants, the Sovnarkhozy are clearly destined to play an increasingly important role.

WHEREAS the Sovnarkhozy are more particularly concerned with technical information, the most important organisation concerned with scientific information is the All-Union Institute of Scientific and Technical Information (VINITI). It is this organisation, formed some ten years ago, which has caused more discussion than any other development in information services, for it represents the ultimate in attempted centralisation of such services. Its main tasks are:

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(a) the preparation of abstracts in the natural and applied sciences, excluding architecture, building, medicine, and agriculture;
(b) the organisation of instruction in scientific information in universities and institutes at undergraduate and postgraduate levels;
(c) the organisation and co-ordination of research into the rational organisation of information activities, and the mechanical and automatic means of processing and retrieving scientific information.

In the preparation of its abstracts, VINITI calls on the services of some 22,000 subject specialists throughout the Soviet Union. Over 17,000 journals are scanned; of these 13,000 come from foreign countries, and will therefore in the main be in a language other than Russian. The abstracts prepared come to over 700,000 a year and are published in *Referativny Zhurnal* which is issued in 24 series representing individual branches of science. In theory this centralisation of activity should make for maximum economy in ensuring that complete coverage is obtained without the duplication of effort entailed when several different agencies are responsible for overlapping subject areas. In practice this advantage is reduced by the frequent necessity to include abstracts of the same papers in two or more of the abstract journals. In addition VINITI has been no more successful than any other large organisation in reducing the time delay in the publication of abstracts. In spite of agreements on the exchange of abstracts with such organisations as the American Chemical Society, abstracts appear only up to six or seven months after publication of the original article. In an attempt to overcome this problem, VINITI publishes *Express Information* 48 times a year in 61 series. This publication contains full abstracts or abbreviated translations of the most important articles and patent descriptions appearing in foreign journals. Each issue has from five to twenty of these shortened articles illustrated by graphs and diagrams. The specialist can thereby obtain a full picture of the original article without spending time on reading a foreign text or obtaining a translation. These articles are published four to eight weeks after original publication and therefore provide a service three to four times quicker than the *Referativny Zhurnal.*

Professor A. I. Mikhailov, who is Director of VINITI, has been appointed recently to the chair of the new Department of Scientific Information at Moscow State University. This department is in part the outcome of the experience obtained over the past five years at VINITI in running, for its own graduate staff, courses in scientific information. It is intended that, at the University, these courses should be given to students in their fourth and fifth (final) years and consist of 400 hours of lectures and practical work split up as follows:

1. Translation of foreign scientific and technical literature ... ... 200 hours

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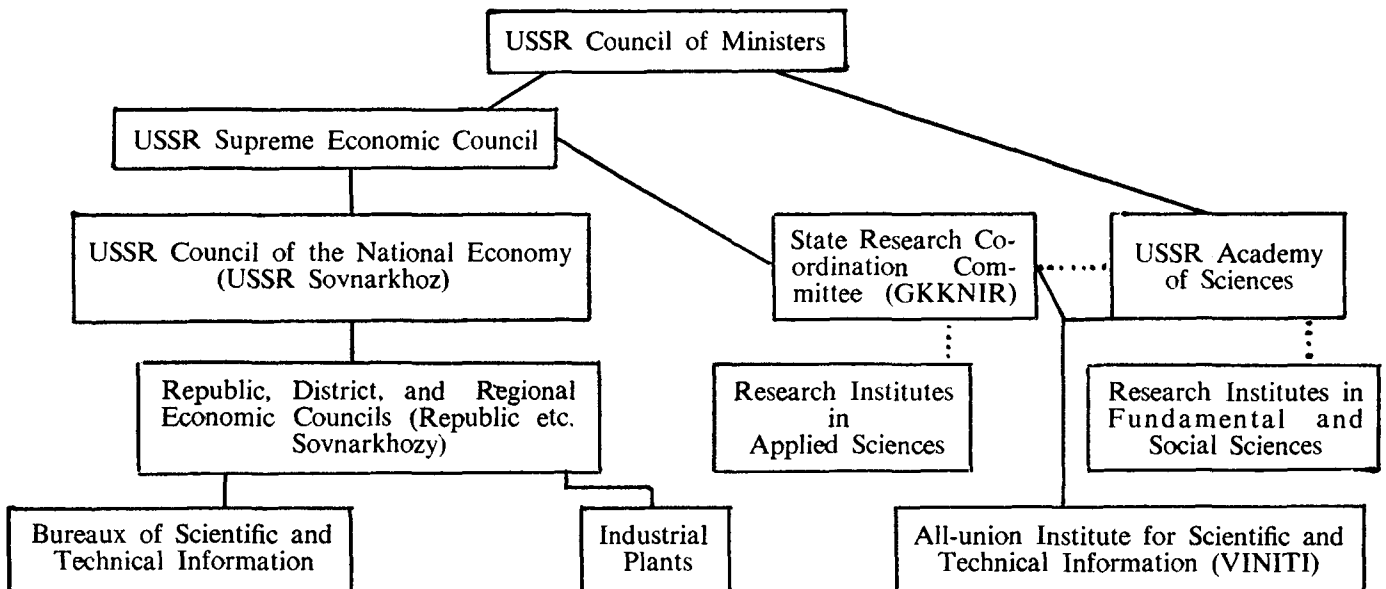
CHAIN OF RESPONSIBILITY FOR SCIENTIFIC AND TECHNICAL INFORMATION


USSR Council of Ministers
USSR Supreme Economic Council
USSR Council of the National Economy (USSR Sovnarkhoz)
State Research Co-ordination Committee (GKKNIR)
USSR Academy of Sciences
Republic, District, and Regional Economic Councils (Republic etc. Sovnarkhozy)
Research Institutes in Applied Sciences
Research Institutes in Fundamental and Social Sciences
Bureaux of Scientific and Technical Information
Industrial Plants
All-union Institute for Scientific and Technical Information (VINITI)

Notes: (i) Research institutions in applied sciences are usually directly subordinate to ministries or state committees other than the Co-ordination Committee.

(ii) The dotted lines imply collaboration or supervision of certain aspects of the work, rather than direct subordination.

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2. The theory and practice of scientific and technical information ... ... 80 hours
3. Bibliography and classification ... ... 30 hours
4. Information journals and publications of primary importance in the corresponding branch of science ... ... 14 hours
5. Scientific abstracting, annotating, and editing 26 hours
6. Fundamentals of mechanical and automatic retrieval; the processing and issuing of information material ... ... 30 hours
7. Fundamentals of polygraphic production ... 20 hours

Considerable emphasis is also placed by Professor Mikhailov on the importance of all students knowing how to obtain rapid access to the literature they require for their work. The Department of Scientific Information intends to organise a course of 30–40 hours for all students at the University on techniques in obtaining and applying scientific information. Opinion is divided as to whether it should be given in the third year or fifth year, and this will probably vary to meet the wishes of different faculties.

VINITI itself will continue to arrange senior specialist courses designed to improve the qualifications and broaden the knowledge of specialists already working in the field of information. Only those with at least a first degree and with experience in the field of information are eligible. In these courses the curriculum consists of a total of 368 hours of theoretical and practical instruction, spread over a period of up to 3 months full time study or up to 10 months for those who can only be spared part time from their place of employment. Apart from the fact that it does not include any instruction on translation, the course covers a similar range of subjects as the University course, but will place more emphasis on such matters as the use of computers in information retrieval. This is in line with the current view in the USSR (and, indeed, in the USA) that, as Academician Nesmeyanov wrote, '. . . the future path of scientific information is the machine. We must recognise this faster and take bolder steps to realise it'.

IT is obvious that, for a country where so great a proportion of the scientific literature is published in 'foreign' languages, the appeal of machine translation should be considerable. During the past ten years a substantial body of theoretical work on this subject has been published. This has had the two main objectives of working algorithms for machine translation from any specific foreign language into Russian, and the development of a single intermediate language to 'bridge the gaps' between the various languages of the world. The linguistic and semantic problems of such a task are considerable and there is no evidence that the efforts of VINITI in this field have produced results which permit one to envisage the day when the human element can be discarded. It is of

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interest to find that the only practical work known to be done in this area is at the Institute of Information of Patents and Inventions. Here, by the use of special subject vocabularies and computers, a word-to-word translation will be prepared of patent abstracts in English. This translation will ignore grammar, and subject specialists will be used to edit the resulting literal translations and put them into correct Russian.

Even if machine translation should prove feasible, it is still unlikely to be economical unless some practical method is found of automatically introducing printed information into the computer. Character recognition by a computer is now a comparatively straightforward operation with formalised type-faces, but in relation to normal printed text, it would not seem that the Soviet Union is particularly far advanced.

A considerable amount of theoretical work on automatic information retrieval systems has been done, with the hope that it will be possible to construct a complete system which will automatically read and store the content of all the world's scientific literature within a long-term memory apparatus. Searching would then be done on the complete store, and the machine would produce actual copies of all relevant documents. Although work is proceeding towards such a sophisticated system, it is particularly noteworthy that there is in the Soviet Union very little practical experience of mechanisation of any kind in operational information retrieval systems.

Apart from an information service such as VINITI, the main national library is the Lenin State Library. Here the emphasis is on traditional library techniques, and in this respect it gives a service which few other single libraries in the world could equal. It is open from 9 a.m. to 11 p.m., and an average of over 7,000 people visit it each day. With 1,700 professional librarians on its staff, it is particularly well equipped to give positive reader service; in addition to maintaining four hundred different catalogues, the Library prepares ten thousand bibliographies each year. The present policy is that priority in receiving bibliographical aid from the Library is given to large construction sites, industrial enterprises, research institutes, and the editorial offices of newspapers and periodicals.

Since the Lenin Library is responsible to the Minister of Culture, it was not affected by a recent ruling of the State Co-ordination Committee that libraries falling within the sphere of its responsibility should use the Universal Decimal Classification. In company with the Moscow University Library and the Academy of Sciences Libraries in Moscow and Leningrad, the Lenin Library is engaged on a major revision of the classification system now in use. This appeared to be fairly conventional hierarchical classification, in which the first class is ' Marxism-Leninism '.

The Lenin Library lends only to organisations, and this is done on a relatively small scale. The main lending library is the Moscow State Public, Scientific, and Technical Library (GPNTB). Some five years ago, the stock at the State Scientific Library was divided between this Library and the new scientific Library in Novosibirsk. In general, the more technological material was retained in Moscow and the literature in the

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more basic sciences was sent to Novosibirsk. GPNTB stands at the head of one system of technical libraries in the USSR and is supported by branches, the central departmental scientific and technical libraries of ministries and committees, and the central scientific and technical libraries of Soviet republics and economic regions. It is responsible to the State Co-ordination Committee.

It is essentially a lending and reference library for scientists and engineers and therefore serves industrial organisations and the scientific research and planning institutes of industry, building, and transport. GPNTB also acts as a central depository for translations and foreign trade catalogues. It is the centre of bibliographic work for science and technology, and among its tasks is that of devising new methods of classification and library routines for use in scientific and technical libraries in the USSR. With 42,000 registered readers and about 3,500 organisations who are regular borrowers, the total number of loans is given as 3 million a year.

IN the field of primary publication, there are 37 publishing houses in the Soviet Union. Most of the houses tend to specialise; for instance, MASHGIZ concentrates on general engineering. This house publishes fifteen journals and up to seven hundred books annually. These latter are intended for a wide range of readers, from the research worker to the workman.

Decisions on what books are required are made by the various specialist state committees in relation to the seven-year economic plan. The MASHGIZ Council controls book publishing policy through its 23 sections, composed of unpaid specialists, scientists, engineers, and Academicians who choose themes, select authors, and vet manuscripts. Besides publishing annually a list of forthcoming titles with authors and synopses, MASHGIZ also publishes each year the forward plans looking further ahead. Both these lists are widely circulated, the first to secure orders from booksellers, the second to secure comments and advice regarding potential authors. MASHGIZ has to approve the author and later the manuscript. Most of the books are written in the author's own time. He receives 60 per cent payment on acceptance of text and 40 per cent when published. Books written in authors' official time, and some books written by distinguished specialists, are not paid for.

In a rather separate category is the Publishing House of the Academy of Sciences, which is responsible for 80 journals and publishes some 1,200 books a year. These latter include books which are the work of Academicians and of staff at the Academy's research institutes, and also a number of works of popular science intended for the educated layman.

Most of the foregoing is a factual account of the present known position with regard to scientific information in the Soviet Union. During a two weeks' visit in June 1963 with a scientific delegation, I had the opportunity of going to fifteen organisations, including those already discussed, as well as libraries in industrial organisations. In the course

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of these visits, one gained impressions which one might not always be able to substantiate with positive facts. Quite obvious to all members of the delegation, however, was the importance which is accorded at the top levels of government and industry to all aspects of the preparation, publication, and dissemination of the results of scientific research and the development and flow of technical information to industry. The close government interest is shown in the chart setting out the chain of responsibility; equally striking was it that at two industrial organisations the delegation met not only the library and information staff but also the chief engineer of the plant. In both cases he led the discussion from the Soviet side and was able to take an active part in the discussion of detail. Where in England one might normally expect to find half-hearted acquiescence in the necessity of an information service, in the Soviet Union there was a real enthusiasm and consciousness of the vital importance of information.

On the other hand, even allowing for the more important role, it did seem that there was a considerable over-staffing at both the professional and clerical levels, and that many professional librarians were engaged on tasks which, in England, would be undertaken by people with lower qualifications. That, for a library of a given size, the staff was four or five times larger than for any comparable library in Britain, could not be explained by any extra services or facilities offered. One could only hypothesise that it was more likely to be due to lower individual efficiency or to the necessity for maintaining full employment amongst a category of educated persons for whom there is a shortage of available posts. It might be of interest to note whether the development of the economy reduces the number who are permitted to go into library work.

Although automation is a leading objective in industry, there appears to be a complete lack of any desire to improve efficiency in what might loosely be termed consumer services, such as shops, restaurants, or libraries. In contrast to the grandiose research project for a completely mechanised information system, we came across very few examples of utilisation of routine methods for saving time or labour, and no attempt to utilise computers in operations which are well within the scope of present techniques. The apparent abundance of labour can readily be accepted as the reason for this. It may also be the case that this is an area where research and development have been deliberately neglected, and that the Soviet Union intends to use the experience gained by other countries. An example of this is the xerographic-type document copying equipment developed in the United States, which, it is said, is now to be manufactured in the Soviet Union.

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PHILOSOPHY AND SCIENCE

Maxim W. Mikulak

THERE is a wide spectrum of views in Western literature concerning the precise relationship of Soviet dialectical materialist philosophy to the natural sciences. John Somerville defended the position that dialectical materialism practically exerts no influence on the growth of Soviet science, and a similar opinion was expressed by Henry B. Mayo, who contended that Russian scientists in general utilise dialectical materialist terminology as a way of paying tribute to the official state philosophy and then continue to employ the scientific methodology common to Western tradition. W. W. Kulski observed that in the philosophy of science only one doctrine is tolerated, but on occasion a Soviet mathematician or physicist must pay lip service to the tenets of Marxism and Leninism. Philipp Frank, who has had considerable contact with Soviet philosophers and scientists, suggested that Soviet dialectical materialism serves at times as a political weapon leading to the regimentation of science in the Soviet state, but Lewis S. Feuer took the more extreme position that dialectical materialism is a 'specific set of conditions imposed on science' and is hindering scientific advancement in Russia. Gustav A. Wetter not only rejected the contention that dialectical materialism is superfluous to the development of the natural sciences, but maintained that Soviet Marxist philosophy commits the natural sciences '*a priori* to specific positions, as an assertion about reality'.[1] Considering the divergent Western views on the relation of dialectical materialism to the Soviet sciences, how clearly and with what consistency has this relation been defined by Soviet communist philosophers and natural scientists?

During the twenties there were at least four major philosophic issues facing Soviet Marxists. The first concerned the necessity of giving philosophy a title to existence in a scientific-socialist society. The second dealt with the relation of philosophy to science. The third was to define the nature of Marxist materialism. The last involved the question of establishing the final authority for the resolution of philosophic disputes.[2] As early as 1922 S. Minin advanced the positivistic argument that there was no need of philosophy in Marxist Russia, and he rested his case on

[1] J. Somerville, 'Soviet Science and Dialectical Materialism', *Philisophy of Science*, January 1945, pp. 73 ff; H. B. Mayo, *Introduction to Marxist Theory* (New York, 1960), p. 49; W. W. Kulski, *The Soviet Regime* (New York, 1959), p. 32; P. Frank, *Philosophy of Science* (Englewood Cliffs, 1957), p. xx; L. S. Feuer, 'Dialectical Materialism and Soviet Science,' *Philosophy of Science*, April 1949, pp. 112, 114; G. A. Wetter, *Dialectical Materialism* (New York, 1958), p. 253.

[2] David Joravsky gives a penetrating analysis of this phase of Marxist philosophic development in his *Soviet Marxism and Natural Science, 1917–1932.*

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Ludwig Feuerbach, Anti-Dühring and *Socialism: Utopian and Scientific.*[3] In due time Minin's name became a pejorative term associated with his anti-philosophic crusade. The *Mininshchina* movement was widespread enough to have *Pravda* publish an article (10 January 1924) condemning the elimination of philosophy from Soviet soil. Eventually a group of professional philosophers, under the leadership of Abram M. Deborin, conducted a campaign to preserve philosophy from extinction.[4] Generally speaking, the Deborinites sought to expand the Hegelian-Leninist philosophic legacy, whereas the positivistic-oriented Marxists, who had the tacit support of many scientists and technicians, sought to subsume philosophy into the natural and historical sciences in harmony with one of Engels' positions. Both factions argued for or against philosophy primarily in terms of Marxist and Leninist literature, and since they treated Marxism-Leninism as a unified, consistent, and cohesive philosophic edifice, reconciliation between the Marxist positivists and the Hegelian dialecticians was ruled out. As a consequence, a commonly acceptable Soviet Marxist definition of the relation of philosophy to science was out of the question. Before one could talk of a relationship between philosophy and science, the more crucial issue of ascertaining the status of philosophy in Soviet society had to be resolved.

In April 1929 the Deborinist dialectical philosophers scored a decisive victory over the positivists and mechanists at the second All-Union Conference of Marxist-Leninist Scientific Research Institutes. This represented a triumph of the Leninist philosophic programme over Engels' subsumptive philosophy, a triumph of dialectical materialism over the mechanistic materialism of the positivists, and a triumph of the dialectical philosopher over the positivist Marxist. However, success left the victors with the problem of establishing the philosophic-scientific inter-relationship. Deborin personally had hoped to evolve a formula for the correct tie of philosophy to science; as the leader of the philosophic front he directed that science be philosophically explored in conjunction with the slogan, 'Reconstruction of Science'. Challenging the Deborinist leadership, V. P. Miliutin accused Deborin and his colleagues of being instrumental in severing Marxist philosophy from the Soviet sciences. Surprisingly enough Deborin admitted this;[5] on 25 January 1931 the central committee of the Communist Party charged the Deborinites with bringing about the separation of philosophy from politics, theory from practice, and the principle of partisanship from science and philosophy.[6] It was obvious early in 1931 that the Party itself, through its 'bolshevising' philosophers, was assuming control of the philosophic front. The decline of the Deborinist leadership

[3] See his 'Filosofiiu za bort!' *Pod znamenem marksizma* (hereafter *PZM*), May–June 1922, pp. 122–127; 'Kommunizm i filosofiia', *PZM*, November–December 1922, pp. 184–198.

[4] R. Ahlberg, 'Forgotten Philosopher', *Survey*, July–September 1961.

[5] *Raznoglasiia na filosofskom fronte* (Moscow-Leningrad, 1931), pp. 7 ff, 26 ff.

[6] 'O zhurnale *Pod znamenem marksizma*', *PZM*, October–December 1930, pp. 1–2.

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marked the termination of the role of the academic philosophers in shaping the future course of Marxism-Leninism.

TOWARDS the end of 1930 and the beginning of 1931 the Presidium of the Communist Academy organised a series of discussions on these questions, at the end of which it decreed that the natural scientists had to support the general line of the Party, build the sciences on the methodology of dialectical materialism, and contribute to the socialist construction of the Soviet Union. This programme was designated as the 'Bolshevisation of Science',[7] but there were no concrete statements on the relation of Soviet philosophy to the natural sciences or on the relationship of Soviet Marxist philosophers to the scientists. The available evidence indicates that the Party leadership intended to subordinate both philosopher and scientist to the Party line rather than have science subordinated to philosophy. While the Party encouraged the Soviet scientists to study dialectical materialism, it did not compel them to embrace Marxism-Leninism.[8] The slogan, 'Bolshevisation of Science,' was interpreted to mean the elimination of the mechanist-positivist and the Deborinist-idealist pockets from the Soviet natural-scientific front, the condemnation of Western idealistic conclusions drawn from modern science, and the implementation of Lenin's principle of partisanship in Soviet science and philosophy. The bolshevisation of science can be understood only in its philosophic-ideological context; it had little to do with science directly. That the Party was opposed to a vulgar permeation of the Soviet sciences with dialectical materialism was strongly hinted by A. I. Stetskii (in *Pravda*, 4 June 1932) who headed the central committee's Department of Propaganda and Agitation; and that the Soviet scientists and Marxist philosophers were not living in marital bliss was pointedly indicated by I. E. Tamm, a brilliant physicist, who denounced the comrade philosophers seeking to bolshevise science on the basis of enthusiastic ignorance instead of scientific proficiency.[9] It cannot be denied that some of the philosophers treated Soviet scientists harshly, but most of their philosophic spleen during the thirties was vented on bourgeois science and scientists. However, the future president of the Soviet Academy of Sciences, Academician S. I. Vavilov, confessed in 1935 that the question of formulating the relationship between Marxist philosophy and Soviet physics was fraught with difficulty.[10]

In the postwar years of Stalin's Russia the philosophic and natural-scientific fronts were dominated by the ideological policy of the

[7] *Za povorot na fronte estestvoznaniia* (Moscow-Leningrad, 1931), pp. 76 ff.

[8] Up to 1931 only 2 per cent of the physicists belonged to the Party and 10 to 15 per cent of the aspirants in physics were said to be Party members. An editorial in *Achievements of the Physical Sciences* considered the apolitical character and the humanism of Soviet physicists detrimental to socialist construction; see 'Ot redaktsii', *Uspekhi fizicheskikh nauk*, No. 1, 1931, pp. 3 ff.

[9] I. E. Tamm, 'O rabote filosofov-marksistov v oblasti fizike', *PZM*, March–April 1933, pp. 220–231.

[10] S. Vavilov, 'Fizika', *PZM*, January-February 1935, pp. 126 ff.

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Zhdanovshchina, and by a controversy concerning the connection of Soviet communist philosophy to modern science. A. A. Zhdanov, who was assigned the task of purging Soviet artistic and intellectual life of capitalist survivals, reverted to the bolshevisers' practice of applying Lenin's partisanship principle to bourgeois scientific thought. By 1952, despite the impact of Zhdanovism upon the intellectual life of the Soviet Union, the editors of *Philosophic Questions of Contemporary Physics* freely acknowledged that many of the philosophic problems dealing with physics had not been resolved.[11] In the same volume (p. 8) Vavilov continued to maintain that the role of philosophy *vis-à-vis* physics was still undecided. This work clearly revealed the reason why Soviet Marxist philosophers were unable to come to grips with the philosophic issues of physics: their general lack of knowledge of modern science. The highly competent Soviet scientist, V. A. Fok, noted this glaring defect in the writings of several Marxist philosophers who criticised modern science more from nescience than from Marxism-Leninism.[12] The mathematician, A. D. Aleksandrov, endorsed Fok's view of the ignorance of science characteristic of some Soviet philosophers.[13] That some of the Soviet Marxist philosophers of science were indeed unprepared to cope with physics from a dialectical materialist point of view was again illustrated beyond any doubt at the Kiev sessions of 1954 on the philosophic questions of contemporary physics. The philosophers not only displayed an inadequate command of physics; it was also disclosed at these sessions that they concentrated on false and trivial matters because they failed to distinguish the scientific questions from the strictly philosophic questions; at the last session K. D. Sinelnikov openly stated that only since the end of the second world war had there been any attempt at integrating the physicists and philosophers in a joint programme, but even this was unsuccessful.[14] The nature of the connection between dialectical materialism and the sciences was as undetermined in 1954 as in 1931 when the bolshevisers occupied the leading positions on the philosophic front.

TWO major philosophic lines for science were adopted by the Communist Party in 1954. The Party opposed any dogmatism in the sciences and simultaneously protested against any philosophic neutralism on the scientific front.[15] Towards the end of that year V. Kuroedov wrote that the 'vital task of the Party organisations is the ideological and political education of the scientific workers and the

11 *Filosofskie voprosy sovremennoi fiziki* (Moscow, 1952).

12 V. A. Fok, 'Protiv neveshestvennoi kritiki sovremennykh fizicheskikh teorii', *Voprosy filosofii* (hereafter *VF*), No. 1, 1953, pp. 168–174.

13 A. D. Aleksandrov, 'Po povodu nekotorykh vzgliadov na teorii otnositelnosti', *VF*, No. 5, 1953, pp. 225 ff.

14 *Filosofskie voprosy sovremennoi fiziki* (Kiev, 1956), pp. 247 ff.

15 'Peredovaia—Nauka i zhizn', *Kommunist*, No. 5, 1954, pp. 3 ff; G. Gak, 'O kategoriiakh materialisticheskoi dialektiki i ikh izuchenii', ibid. No. 13, 1954, pp. 18 ff.

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inculcation of Marxist-Leninist theory'.[16] The seemingly contradictory policies of discouraging dogmatism in natural science and yet bridling it with the tenets of dialectical materialism have continued to the present and remain in effect. The scientists are continually reminded of the partisan nature of philosophy and science; an unsigned article in *Party Life* (No. 9, 1956) notes that the liquidation of the cult of personality had created a new atmosphere for science, and that Party organisations must wage a struggle against indifference to principles on the scientific front. The campaign against this indifference appears to have been far from successful; the positivistic susceptibilities of Soviet scientists provoked an attack by the president of the Soviet Academy of Sciences at the All-Union Conference on the Philosophic Questions of Contemporary Natural Science in October 1958.[17]

For their part, the philosophers gave greater attention to the value of Marxism-Leninism for natural science. G. V. Platonov maintained that if scientific experiments were isolated from dialectical materialism science suffered idealistic and metaphysic distortions. He criticised the philosophers of Moscow State University for diluting Marxism-Leninism by converting it into categories of thought; their approach would inevitably cause a cleavage between philosophy and natural science; at the same time he admitted that there were members of the Soviet scientific community who brooked no interference from the philosophers in developing the theoretical problems of science.

M. N. Rutkevich had a section on the importance of Marxism-Leninism for science and practice in his *Dialectical Materialism* (1959). He defined dialectical materialism as the generalisation of the factual material developed by the natural and social sciences and by practice, as the philosophy of Marx for transforming the world, and as a method of thought that gives the scientist the correct orientation for solving theoretical problems. How to transfer the dialectical materialist method of thought to the laboratory was not made explicit.

In 1960 a collection of articles on dialectical materialism was released for higher Party schools.[18] In the first paper, on 'The Subject of Marxist-Leninist Philosophy', A. V. Vostrikov characterised Marxist-Leninist philosophy as being 'based on the facts of science and practice that profoundly reveals the most general laws of the development of the world and simultaneously arms the people with the scientific method of knowledge and the revolutionary transformation of reality' (p. 5). He noted that dialectical materialism not only makes known the most

[16] V. Kuroedov, 'Partiinye organizatsii i nauchnye uchreshdeniia', ibid. No. 18, 1954, p. 64.

[17] Cf. 'Peredovaia—O razrabotke filosofskikh voprosov estestvoznaniia', *VF*, No. 3, 1957, pp. 4 ff; I. Narskii, 'Filosofiia neopozitivizma i nauka', *Kommunist*, No. 13, 1955, pp. 70–85; A. Topchiev, 'Stroitelstvo kommunizma i nauka', ibid. No. 13, 1957, pp. 80 ff; M. D. Kammari, 'Revizionistskii mif ob "osvobozhdenii" nauki ot ideologii', *VF*, No. 7, 1958, pp. 3–19; *Filosofskie problemy sovremennogo estestvoznaniia* (Moscow, 1959), pp. 6 ff.

[18] A. D. Markov et al., eds., *Dialekticheskii materializm* (Moscow, 1960).

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general laws of nature, but seeks also the most general interconnections of natural processes. It is a scientific method of cognition for the natural and social scientists; scientists, he writes, are eventually forced to consider philosophic problems. To what extent dialectical materialism can help a scientist to advance science proper is a question left unanswered by Vostrikov.

In an article in the same volume on 'Dialectical Materialism and Contemporary Natural science', E. N. Chesnokov defends the proposition that dialectical materialism furnishes the methodological foundation for modern science; Marxist-Leninist philosophy is said to have infused natural science with the idea that the material universe is interrelated and is infinitely diverse in form. The severance of philosophy from science; the belief that science is itself a philosophy; and the concept of philosophy as a universal scheme are described as trends alien to Marxism-Leninism. He notes that little work has been done on the specific contradictions existing in the development of nature—are antagonistic and non-antagonistic contradictions evident in nature?—and observes that Soviet philosophers and scientists falter in handling quantitative and qualitative changes in nature according to dialectical laws. On these basic philosophical problems there appears to have been little progress since the twenties.

HAS the nebulous pattern established by Soviet Marxist philosophers on the link between philosophy and science been duplicated by Soviet scientists or not? In none of the technical works of Soviet scientists reviewed by this writer was any overt use made of the dialectical laws of thought or of the characteristic methodology of dialectical materialism. Eric Ashby did discover one Nikolai Petrovich Krenke who consciously applied the teachings of dialectical materialism to research on plant development, but he also stated that Krenke's research could have been conducted without recourse to dialectical materialism.[19] Soviet scientific treatises containing remarks on dialectical materialism as the guiding philosophy or methodology rarely reveal in detail how it is in fact utilised. For example, in the preface to a series of technical papers on theoretical astrophysics V. A. Ambartsumian wrote: 'Soviet scientists who work in the field of theoretical astrophysics are guided by the method of dialectical materialism, and always link their work to reality, using mathematical and physical methods as an important and powerful means of studying the heavenly bodies.'[20] The writer does not say whether the method of dialectical materialism is identical with the conventional mathematical and physical methods or not. Nor does any Soviet astronomer represented in this collection of papers on theoretical astrophysics exhibit any overt influence of dialectical thought. In the introduction to *The Theory of Space, Time and Gravitation* V. A. Fok writes that Lenin's *Materialism and Empirio-Criticism* helped him to

[19] E. Ashby, *Scientist in Russia* (New York, 1947), pp. 100 ff.
[20] V. A. Ambartsumian, ed., *Theoretical Astrophysics* (New York, 1958).

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re-evaluate Einstein's theory of relativity from a dialectical materialist point of view.[21] It would have been an invigorating experience if Fok had said *how* Lenin's book had helped him to convert Einstein's theory of *relativity* into a theory of *gravitation*. What Ernest Nagel had to say about scientists and philosophers in general certainly applies to the Soviet scene: 'But like a chaplain's prayer at the end of a political convention, the philosophies ceremoniously professed by most men of science are largely irrelevant to the accredited body of scientific knowledge'.[22] The Soviet scientists have shed as little light on the nexus of philosophy to science as their philosophic counterparts.

There are certain features of Soviet dialectical materialism itself that tend to preclude the possibility of formulating a fructifying relationship between philosophy and science. Engels conceived dialectics to be 'the science of the most general laws of *all* motion,' and he extended this concept to the areas of natural science, human history, and thought.[23] These general laws are no more than the Hegelian laws of thought: the law of the transformation of quantity into quality and vice versa, the law of the unity and the struggle of opposites, and the law of the negation of the negation. These laws are said to be *abstracted* from nature, human society, and thought. According to V. M. Kovalgin, these three dialectical laws reflect the most general interconnections inherent in nature, society, and thinking,[24] but he does not explain how they can be used in the solution of scientific problems. Nor does he make plain what advantages the dialectical laws have over the present techniques employed in scientific research. Rutkevich, too, recognises the existence of the most general connections and laws of material development, which, he says, distinguish dialectics from the natural and social sciences. Aside from the fact that the dialectical laws are of a general nature and the scientific laws are of a specific nature, Rutkevich cannot correlate philosophy and science.[25] The problem of linking the general with the specific was discerned by some Soviet authorities as the *vexata quaestio* to be resolved before any practicable relationship between philosophy and science can result. P. N. Fedoseyev suggested that the most important question confronting Marxist philosophers is to ascertain the cognation of the general, which he identified with philosophy, and the specific, which he identified with science, and that this question is one facet of the broader problem concerning the bearing of quantitative changes upon qualitative changes.[26] Fedoseyev made these remarks in June 1960, at a meeting on the philosophic aspects of natural science, and his statements are further proof that as late as the summer of 1960 no clear-cut relationship

21 V. A. Fock, *The Theory of Space, Time and Gravitation* (New York, 1959), p. xviii.
22 E. Nagel, *Logic without Metaphysics* (Glencoe, 1956), p. 317.
23 F. Engels, *Dialectics of Nature* (Moscow, 1954), p. 353; *Anti-Dühring* (Moscow, 1954), pp. 195, 510.
24 V. M. Kovalgin, *Dialekticheskii materializm o zakonakh nauki* (Minsk, 1958), pp. 88 ff.
25 M. N. Rutkevich, *Dialekticheskii materializm* (Moscow, 1959), p. 280.
26 I. D. Andreyev and I. I. Ionov, 'Zasedanie biuro nauchnogo soveta po filosofskim voprosam estestvoznaniia', *VF*, No. 10, 1960, p. 147.

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between dialectical materialism and science was perceptible. S. I. Vavilov showed awareness of the general-particular issue as early as 1935; in the intervening years it came no closer to solution.[27] In a recent article I. V. Kuznetsov defended the validity of the most general laws of development. He examined the question of expressing these laws in terms of physical processes, but provided no tangible illustrations of their application to the natural sciences. From Kuznetsov's 'No! Philosophy is a Science' it is not clear whether the dialectical laws of thought and development are heuristic guide lines for research or whether they are actual scientific laws embodying physical relationships.[28] Even B. M. Kedrov's 'Philosophy as a General Science' throws only a dim light on the tie of the general with the specific.[29] So long as dialectics is viewed as the most general laws of development, and so long as Soviet philosophers cannot surmount the hiatus between the general and the particular, the task of establishing the nexus between philosophy and science in meaningful terms must be viewed as beyond fulfilment.

THE contention that dialectical materialism is abstracted from the natural and social sciences and from human thought raises another question concerning the chasm between Soviet communist philosophy and the sciences. It is alleged by Marxist philosophers that dialectical materialism is a scientific outlook derived from science itself. If this indeed be the case, how sharp is the distinction between dialectical materialism and the sciences? The only distinction separating the content of these two areas would be the degree of abstractness of dialectical materialism in contrast to the natural sciences. But in the terms of the given argument dialectical materialism cannot be regarded as a distinct field of knowledge; this position leads to *Mininshchina* and positivism. However, no Soviet philosopher would go so far as to merge Marxism-Leninism into the natural sciences. And if dialectical materialism is not derived from the sciences can it claim that it is truly a scientific outlook?

There is also the question of determining the utility of philosophy for the natural sciences. A. F. Samoilov challenged the Deborinist dialecticians in 1926 to produce superior results in solving scientific problems by way of philosophy.[30] Samoilov's challenge was recognised as a serious one, but in all the philosophic works covered in this essay not one Soviet philosopher has demonstrated the value of dialectical laws for scientific research. Ernest Kolman asked whether Einstein's philosophic views aided him in his work or not, but he gave no precise answer to this question, vital from the Marxist point of view.[31] In 'Science and a World Outlook', A. Bovin said that at first glance the

[27] S. I. Vavilov, *op. cit.*, pp. 127 ff.
[28] I. V. Kuznetsov, 'Net! Filosofiia—eto nauka', *VF*, No. 1, 1962, pp. 115 ff.
[29] B. M. Kedrov, 'Filosofiia kak obshchaia nauka', *VF*, No. 5, 1962, pp. 44–58; No. 6, 1962, pp. 48–62.
[30] A. F. Samoilov, 'Dialektika i estestvoznanie', *PZM*, No. 4–5, 1926, p. 81.
[31] E. Kolman, 'Kuda vedet fizikov subiektivizm', *VF*, No. 6, 1953, p. 181.

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results of science are not dependent on the philosophy of scientists. After all, both idealist scientists, including Bohr, Heisenberg, and Wiener, and materialist scientists, Langevin and Pavlov, did excellent scientific work; Bovin was aware of this, but instead of exploring this theme further he launched into a discussion of the political and ideological atmosphere of the idealist scientists, and never drew the unavoidable conclusions on the role of philosophy in scientific research.[32] The Ukrainian expert on Leninism and modern physics, M. Omelianovskii, asserted that the Marxist revolution had transformed previous philosophy into a science over the sciences in methodology. Did he mean that dialectical materialism ought to displace the traditional mathematical and experimental methods of the physical sciences? The answer, according to Omelianovskii, is no; philosophy provides only the correct philosophic solutions to the problems of physical science. He also maintained that dialectical materialism allows a scientific theory to develop properly, but, learned as Omelianovskii is on Leninism and the physical sciences, he simply could not link dialectical materialism directly with the natural sciences.[33] At best, he showed that philosophy is pertinent to the investigation of the *philosophic* problems of science.

Not only have the Soviet Marxists thus far failed to establish a workable formula integrating philosophy with the sciences; some Soviet philosophers have actually played a regressive role in the growth of science in the Soviet Union by their philosophic meddling. A leading editorial in *Kommunist* (No. 5, 1954), disclosed that the central committee of the Soviet Communist Party at its plenary sessions of February and March 1954 had sharply criticised dogmatism in the agricultural sciences. Furthermore, the Soviet philosophers came under special attack because their chief contributions to the building of communism were the compilation of citations and the production of commentaries on the classics of Marxism and Leninism. The Soviet physicist, S. L. Sobolev, emphasised in *Pravda* (2 July 1954) the necessity of having healthy scientific criticism to encourage innovation and progress in science. He condemned the notorious Soviet agronomist, T. D. Lysenko, and his students for displaying dogmatic tendencies in their controversy over genetics. (Lysenko, in collaboration with the polished Stalinist philosopher, I. I. Prezent, endeavoured to discredit genetics on philosophic-ideological grounds.[34]) At the All-Union Conference on the Philosophic Questions of Contemporary Natural Science the Armenian astronomer, V. A. Ambartsumian, frankly stated in his report, 'On some Methodological Questions of Cosmogony,' that Soviet philosophers have hampered the progress of Soviet astronomy.[35] And the internationally renowned Russian physicist Kapitsa called attention to

[32] A. Bovin, 'Nauka i mirovozzrenie', *Kommunist*, No. 5, 1960, pp. 96–107.
[33] M. Omelianovskii, 'Dialekticheskii materializm i sovremennaia fizika', ibid. No. 5, 1956, pp. 72–87.
[34] See *The Situation in Biological Science* (Moscow, 1949).
[35] *Filosofskie problemy sovremennogo estestvoznaniia*, op. cit., p. 290.

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the fact that Soviet dialectical materialists had rejected cybernetics, the quantum theory, the resonance theory of the chemical bond, the theory of relativity, and had committed blunders in biology; if Soviet scientists had accepted the leadership of the philosophers in 1954, he said, it would have been impossible for them to conquer the cosmos.[36] One can unhesitatingly agree with the Soviet Estonian philosopher, G. I. Naan, when he stated that the nihilistic attitude of some Soviet Marxists towards modern science will lead the enemies of the Marxist-Leninist world view to question seriously the ability of dialectical materialists to cope with the problems of modern science.[37] By 1958 it was possible to recognise a trend on the part of Soviet Marxist thinkers and natural scientists to keep their respective areas of inquiry autonomous and free from outside interference despite resolutions calling for unity and close cooperation between philosopher and scientist. At the same Conference the outspoken philosopher, N. F. Ovchinnikov, suggested that philosophers could ensure the correct philosophic interpretation of modern science without external aid, and that philosophic problems were a unique domain of study distinct from the natural sciences.[38]

At one time or another Marxist-Leninist philosophic authorities have said that dialectical materialism is not a science over the sciences, nor is it below the sciences, nor is it separated from the sciences, and nor is it identical with the sciences. It is a most frustrating task to uncover any consistent, positive, and unambiguous explication by Soviet philosophers and scientists on the exact nature of the bond between dialectical materialism and the sciences. The existence of the bond appears as elusive as the missing link between Hominidae and Pongidae. So long as this bond is not clearly defined the state of confusion surrounding the Soviet application of dialectical materialism to the sciences is bound to continue. However, it is becoming increasingly evident since 1954 that Soviet philosophers are resuming genuinely philosophic studies along the lines mapped out by A. M. Deborin and his colleagues.[39] And it is also becoming increasingly evident that both the Soviet philosopher and the Soviet scientist have singular problems and singular methodologies, and have made singular contributions to the totality of human knowledge. Modern science can in part trace its origin to the Franciscan outlook that divided reality into the spiritual and the natural. It is tempting to conclude that the basically monist nineteenth-century Marxist-Leninist philosophic schema is in process of succumbing to some form of pluralism in order to accommodate the outlook of twentieth-century science and to maintain peace in the no-man's-land between philosopher and scientist.

[36] P. Kapitsa, 'Teoriia, eksperiment, praktika', *Ekonomicheskaia gazeta*, 26 March 1962.
[37] *Filosofskie problemy sovremennogo estestvoznaniia*, op. cit., p. 416.
[38] Ibid. pp. 454–455.
[39] The return to customary philosophic problems by some Soviet Marxists is documented in *Studies in Soviet Thought*, ed. by J. M. Bochenski and T. J. Blakeley (Dordrecht, 1961).

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SCIENTISTS IN SOVIET LITERATURE

Alexander Steininger

WORK in one form or another is still *the* subject of Soviet literature: work for the good of the state, work for national ends, and above all work as the saving ethical principle. Man is usually displayed in the closest association with work, and work—utilitarian, practical work—is made almost the sole criterion of character.

What, as reflected in these writings, are the outstanding features of the Soviet scientist today? And what are the problems confronting him?

Some of the answers are provided in the short and attractive story by V. Kaverin entitled 'Kusok stekla' (A Piece of Glass, *Novy Mir*, 8/1960). Kaverin takes us into the internal self-sufficient world of scholars who live for their own tensions and intrigues. Intrigues as such are of course by no means a specifically Soviet phenomenon, but the causes which produce them and the frank admission that a self-contained 'world' can exist in the Soviet Union, so to speak outside the system, seem worth attention. The story is quite simple. Petya Uglov, a young scholar from Perm concerned with some difficult problems of physiology, comes to Leningrad in order to have made in the Institute for Glass a small piece of very special glass for his apparatus. This should have presented no difficulty, since an order from the scientific head of the Institute, Kruaze—he represents, as it were, the administrative centre—would be sufficient. But Kruaze refuses to give the order without the consent of Evlachov, the figure representing the psychological centre. What lies behind this refusal is not apparent to the outsider; it stems from the personal enmity of the two scientists. The cause of their mutual hostility appears to be typical of prevailing conditions. It started in this way: a rather colourless book, based on antiquated conceptions but laying claim to a certain depth, was submitted to the Institute for an expert opinion. Both scientists agreed that the book, by the head of a government department who 'dreamt of a science degree', was bad and quite unsuitable as a text-book. Evlachov composed a critical notice of the book, with which Kruaze agreed but which he did not sign because 'it was simply not necessary'. At a conference held shortly afterwards, however, Kruaze spoke up most warmly for the book in a paper he had prepared some time before. Furthermore, he accused Evlachov and other critics of the work of inflicting great damage on the Institute's long-term plan by their negative attitude. This particularly objectionable form of servility, not unknown elsewhere, is encouraged by the conditions imposed by the communist system.

Valya, Petya's friend, and also a scientist, describes Petya's experience in the Institute as characteristic. More familiar with the 'secret world of the Institute', he says that the incident is 'an expression of the

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struggle that never ceases for a single day in the world of science'. Only the forms it takes differ. The struggle, fought out mainly between the 'old men', leads to these scientists actually being lost to science itself; they devote themselves entirely to their own plots and intrigues. And Valya goes on: 'I know a gifted scientist who has given up his own research altogether and delegated it to his assistants so that he can give his whole time to the relationships between his institute and other institutes, between Academy member A and Academy member B; yet it would be wrong to say that he is pursuing any particularly avaricious end! The point is that he cannot live without these things, just as some people cannot live without wine and cigarettes.'

And the two young scientists come to the conclusion that 'the old men are in the way'. However, the 'old men', or rather the 'bigwigs' of science among them, have the last word.

THE problem of the generations in the Soviet Union, which has certain political aspects all its own, has now become *the* problem. However, Kaverin's Petya believes that it is above all a 'vertical problem, a problem of time': 'Some live for the interests of tomorrow, whilst others cannot part from yesterday.' The fact that the 'bigwigs' do play a very special part in Soviet science is nevertheless confirmed by the way the young men set all their hope on 'the tremendous—and not least psychological—displacement which has taken place in our science in recent years' (as a result of destalinisation).

In one respect, however, the younger scientists still seem to be treading the same paths as their teachers. They too shut themselves off and create a world of their own which it would be difficult to call typically 'Soviet'. Kaverin's Petya Uglov gave himself up to science when he was only seventeen, and attained 'a depth that was full of promise; he had in fact already achieved a great deal, although he was still quite young. He had such a subtle understanding of science that he had learnt to assess people mainly in accordance with their attitude to science. He had a clear understanding of the different types of scientist, their tactics and their strategy, their passions and their weaknesses. On the other hand, the world of ordinary non-professional emotions was quite alien to Petya Uglov, as it is to most of his contemporaries who have remained wholly undeveloped in the art of human relationships, in love, in the ability to appreciate beauty, and in the capacity for enthusiasm.'

These characteristics, typical, according to Kaverin, of the majority of younger scientists, are also to no small extent the outcome of the education they have received. General all-round education is neglected and, remembering that most of the students and scientists of today come from humble circumstances and cannot rely at all or only very inadequately on the family as an educating or even merely civilising factor, the neglect is not surprising. Valya notes almost with a touch of envy that the 'old men' have an understanding of good manners, and he adds, regretfully, turning to Petya: 'Neither you nor I know how to

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enter a house or how to leave it, or how to greet anyone properly (po-chelovecheski), or carry on a conversation'.

In other words, what this younger generation of scientists lacks is a certain high level of culture, the kind which, more than any specialist knowledge, typified the old Russian intelligentsia. It is not surprising that the direct transition from the working or peasant class to the level of the Soviet intelligentsia, of which the scientists represent the cream, is not always effected without pain. The young men who—leaping over enormous stages of evolution—have been forced, so to speak, to fill a vacuum, do seem, however, by reason of their knowledge or rather their acquired ability to think in abstract categories, to be overcoming their exceptional isolation and in the process of working out their own ideas about life and things in general to be making contact with the traditions and accumulated cultural values of Old Russia.

How else could it be explained that Petya Uglov, who has never been to Leningrad before, has long had a special liking for that city—not merely for its role during the revolution but for everything that was once associated with the name of St. Petersburg. 'He read everything about it, everything he could lay his hands on, and not only in Russian. He saw all the films from Lenfilm [the Leningrad film studio] because the action often took place in the streets of Leningrad. From time to time, though he had no money to spare, he bought old engravings and studied in great detail the dark-white smoke-coloured buildings along the banks of the Neva which were delineated with such fine strokes.'

The usual spare-time occupation of Petya also deserves mention—he meditates. This, as well as the state of his room, show very obviously and so to speak symbolically, the present 'uncouth' condition of the 'young' and the way it may be overcome: He had 'a room which, although a very good one and in a new house, was half empty, with great piles of various kinds: piles of cigarette-ends, piles of books on the floor, the window-ledge, and the divan. His way of life, on returning from work, was to stretch himself out comfortably on the divan, to smoke, and to meditate'.

One more thing seems noteworthy in this story of Kaverin's which throws so much interesting light on our theme—the young scientist Petya Uglov does not think of the distant 'shining goal', nor of the immediate utility of his work for the 'good of the people', nor even for 'the cause of world communism'. He is simply concerned with scientific knowledge as such.

KAVERIN'S story 'Poiski i nadezhdy' (Seeking and Hoping) appeared in the now almost legendary second volume of the collective work *Literaturnaya Moskva*, and represents the third part of his trilogy *Otkrytaya kniga* (Open Book). Also set in a scientific milieu, it describes, among other things, the so to speak official difficulties in the development of Soviet penicillin, and shows in a courageous manner 'the monstrous forms of the struggle that has been going on for years in

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the sciences'. It is true that the story takes place mainly during the war and the immediate post-war years, that is, during Stalin's lifetime; the men who wage the struggle for power and position are usually not genuine scientists but mere upstarts who owe their posts to their diplomatic skill in the world of scientific politics and above all to the frightful opportunities which the regime affords them (and in particular afforded them at that time); they are men 'who feel insecure in laboratories, but very secure at meetings and in the people's commissariats'. They are unscrupulous and shrink from no vileness—a fact that Kaverin brings out most impressively. They are even prepared to commit (indirect) murder. Their weapons are intrigue, defamation, and denunciation—but they leave the executions to the regime.

The enemies of the mould (penicillin) which disturbs their often very complicated and impenetrable plans, based not least on personal feuds, have a complete mastery of their art. These people are anything but clumsy; they consider every step very carefully and shoot their arrows at precisely the right moment, against one another as well as against their enemies. Kaverin's hero has the good fortune to survive and even to be rehabilitated. But how many were not so lucky?

It is well known by now that this kind of system, combined with the very difficult situation of the time and with the directives 'from above', had an extremely destructive effect on scientific research. Kaverin puts it like this: 'Oh this mystery, this darkness, in which we were scarcely able to distinguish one another. Even now—and I am writing this in 1956—we have not yet settled accounts with that ignorant nonsense, with that mysterious piffle surrounded by barbed wire fences which was kept locked up in safes after working hours. How many clever people who had no sort of contact with medical science attained high positions under the cloak of this artificial secrecy without which it was for some reason or other impossible to work or live. This would-be science needed a would-be inspiration—and to this end wide-ranging discussions were organised to show the world the splendour of creative activity and the clash of opinions. But under this artificial light only the lifeless decorations of dogmatism, ready-made ideas, and dictated thoughts were visible.'

SO much for the years immediately after the war. What of the present? Let the writer I. Grekova take us into laboratory no. 10 in an institute directly concerned with space problems, a subject that is being treated more and more frequently in literature. With her story 'Za prokhodnoy' (roughly, Behind the Control Room, *Novy Mir*, 7/1962), Grekova went beyond the stage of vague hints and commonplaces and dealt in a thoroughly realistic way, though nowhere exceeding the bounds of the strictly permissible, with everyday life in a laboratory where the research work is subject to secrecy.

The assistants in the laboratory are all young scientists, most of them already with a doctor's degree—a close-knit team with a deep mutual

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understanding and a shared enthusiasm for, even an obsession with, their work, for its own sake. Their task, in which they all take a really personal interest, is concerned with complicated scientific and technical problems and they pursue it without any ulterior motives. Neither the Party nor the State appears in this story in any form at all. They simply do not exist. There is only the creative atmosphere of a team keen on its job. It is perfectly credible that, as Grekova says, these young scientists should protest against the seven-hour day and the strict observance of office hours, and ask for permission to work in the laboratory after closing time: 'I have perhaps—one of them says—thought all day and discovered nothing at all; and then just before six it comes at last. And suddenly the bell goes. Right in the middle of the new idea.' They even decide to organise a kind of sit-down strike and pay no attention to the bell.

It is typical of the mutual relationship of these lab assistants that they are all on Christian name terms—even down to the mechanic—and by no means fussy in their choice of language. But no one takes this amiss. Most of them have nicknames: Zenka the poet, Vovka the wise, who has lost his sight while conducting an experiment, Klara three-cakes, Vovka the critic, and a third Vovka who has apparently never read anything and imagines Vietnam is in America.

This gallery of young scientists seems quite typical of the rising generation of scientists in the Soviet Union. They live in their own special world and pursue their research for its own sake, not for the purpose of the regime. This difference in outlook (to be observed in other professions as well) may one day become a big problem for the regime, if it is not already.

It is, incidentally, interesting that accidents and breakdowns are no longer concealed. 'Vovka the wise' lost his eyesight in an experiment; in the entrance hall of the institute where he works there hangs the portrait, framed in mourning crepe, of a young man who 'lost his life in the course of fulfilling his official duties'. Victor, in Aksenov's *Ticket to the Stars*, also loses his life 'in the fulfilment of his official duties' in an aeroplane disaster. In Granin's highly interesting novel *Idu na grozu* there is a detailed description of the crash of an experimental aircraft in which a young scientist loses his life. A disastrous accident that occurs during the testing of a new fuel for rockets is also described in Chakovsky's *Light of the Distant Star*. This taboo, at any rate, has been partly broken.

IT is typical that the working conditions in Grekova's institute are quite modest. The institute lies on the edge of a large town in the midst of a bleak and barren countryside. It can only be reached by a broken unpaved path covered in mud. The large brick building is surrounded by a solid brick wall with barbed wire all along the top. A sentry stands outside the big iron gate.

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Laboratory no. 10 consists of several rooms: the laboratory proper, the preparing room, workshop, and dark room. Apart from the chief's room there is only one room for desk work: 'The walls are dull, yellowish-grey, and badly painted'. The room is narrow, the cheap writing tables stand side by side. Calculating machines clatter, the telephone rings incessantly, the noise is sometimes so great that the occupants have to shout to make themselves heard. These conditions seem to make for unpretentiousness, an enhanced adaptability, often combined with a great gift for improvisation.

A similar picture emerges from Yaroslav Golovanov's 'Forge of Thunder' (*Yunost*, 1/1964), which is set in the same milieu though the writing is nothing like so vivid. He takes us into a research centre for space rockets near a small town almost on the Afghan border. The main characters are a team of young scientists working in a large bright room five men and a woman—'Six out of thousands just like them'. (Incidentally, there is a brief preface by the cosmonaut Nikolaev.)

Golovanov discloses rather more of the private circumstances of his heroes; these are, at least by our standards, very modest. The head of the team, Dr. Kudesnik, is harassed by many everyday cares: 'Hardly had he left the control room than countless minor worries moved in on him from every side. They clung to him like red ants, they crawled under his clothes, they stung him and there was no hope of running away from them or shaking them off. At one moment his mother needed some medicine or other and there was none in any chemist's shop; at the next moment the workmen were arriving to start repairs in his house and for the next terrible month he was going to live the life of a caveman . . . Then he had to take a coat to be cleaned. This small matter also developed into a problem because things for cleaning were only accepted in the forenoon, just when both he and his wife were on duty . . .'

We also meet in Golovanov, though from a rather different point of view, the phenomenon of the scientist's isolation from the outside world. Kudesnik notes regretfully that the world of entertainment and amusement had 'long since passed him by. He felt that he had departed from this world and lost all contact with it. And the reason was not that he could not, for example, attend this poetry evening. Of course he could. He did actually go. Very seldom, but nevertheless he went. But when he went and listened to the poems and looked at the people sitting beside him, he felt a kind of incomprehensible estrangement, he felt that it was an accident that he was in the room at all.'

But it would be quite wrong to think of these young scientists spending their whole time thinking, brooding, and in seclusion. The picture of young physicists that Daniil Granin draws in his novel *Idu na grozu* is probably typical of a not inconsiderable part of the rising generation of Soviet scientists—tense, concentrated work but at the same time youthful vigour and vivacity: 'On Saturdays they invited girls to the café "Sever" or to the "House of Scientists"; they showed off in tight trousers and coloured shirts; they liked to be taken for angry young men

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—go on, they seemed to say, grumble and be angry. The girls, dressed in tight skirts with outrageous slits, drove the more refined ladies out of the " House of Scientists ". And the dance tunes of the 1940s, legally recognised so to speak, did not stop them jiving with an abandon that made it difficult for the older people to believe their eyes. After leaving the " House of Scientists " they would go to someone's place to drink wine and sing popular songs, and fervently discuss the music of the future and the paintings of Picasso. They listened to ultra-modern jazz on tape, but midnight usually found them discussing the relation between micro- and macrocosm, radio-astronomy, cybernetics, in other words, the things that at that time filled everybody's mind—amateurs and professionals alike.'

THESE young physicists are also anxious to come to grips with both the distant and the recent pasts of their country: 'For them the stories of Babel, which had just appeared, and the sketches of Koltsov were real discoveries, like the poems of Tsvetaeva and the documents that were unknown under Stalin. They were most excited by the problems arising from the personality cult; eagerly and self-confidently they rebuilt this imperfect world '.

Daniil Granin, originally an engineer by profession, often makes technicians, engineers, and scientists the central characters in his works. In his politically completely orthodox novel *Iskateli* (The Seekers) that appeared in 1954, he is concerned with the development of a particularly accurate radio-location apparatus for the identification of circuit faults. Obsessed with the idea of this instrument, Dr. Lobanov, the hero of the novel, leaves the university, in spite of the fact that his professor has chosen him as his successor, to become, at a substantially lower salary, the head of the laboratory of the Leningrad generating station. It is only there that he can develop and test his apparatus. What has spurred him on is the fact that the instrument is urgently needed by many thousands of mechanics.

The research work which Lobanov has to do in connection with the new apparatus is ideologically perfectly respectable since it serves a tangible end. The practical utility of science and research was and still is the supreme principle for scientists in the Soviet Union, although there has been a certain relaxation in recent years and scientists now have a better chance of pursuing their own paths.

As is but fitting in a politically orthodox novel, Lobanov does not succeed in completing his apparatus without the aid of the Party. He overcomes internal difficulties in the works with the help of the leader of the laboratory party cell and he wins the battle against his enemies outside the works with the support of the secretary of the City party committee. The ever-present Party is the really determining factor in every activity.

Granin's novel *Idu na grozu* which appeared in 1962, eight years later, takes place in a similar setting and is based on analogous conflicts,

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but proceeds from different assumptions. It documents the changes that have taken place in the Soviet Union since the death of Stalin. The basic framework of the novel is provided by the work of a group of scientists who are investigating the natural processes operating during a thunderstorm or inside a storm cloud. But that is merely the background. The important thing is the change that has come about in the author's approach. The novel is in fact a gigantic picture of the inner world of science with all its tensions and conflicts, the result to a not inconsiderable extent of the conditions imposed by the regime. It brings before our eyes the positive and negative types of this special world—young and old scientists who have dedicated their lives to knowledge, and also the pseudo-scholars and careerists who misuse science for their own ends, discrediting and betraying it by their noisy promises of quick returns.

The main character of the novel, the young scientist Sergei Krylov, is, unlike Lobanov, not a 'Soviet man' but simply a man—and this is not the least important source of the many difficulties he has to overcome. With the utmost intensity he attacks the pseudo-scientific efforts of some of his colleagues and condemns all utilitarianism in science, like his teacher Dankevich, known as Dan, who behaves in a most unorthodox manner at a press conference:

> To begin with Dan refused to answer the question as to approximately how long the work would last; then he began to laugh sarcastically at his questioners: it might perhaps last entire decades or it might finish tomorrow, but it was also quite possible that he himself would not live to see the work completed—but this did not cause him any kind of distress as he was convinced that even members of the Commission would realise that to work only for the present day and age and to avoid any potentially dangerous undertakings which might need many years to complete, is a typical form of poaching. Such an attitude would never produce any Tsiolkovskys . . .
>
> What then is the purpose of your researches? asked the journalist.
>
> We are striving after scientific knowledge.
>
> How will that benefit our technology?
>
> It won't benefit it at all, not at all . . . you think we ought to be increasing the output of cast iron—but we are not going to.

This is of course a new approach. Even if the value of basic research has not been denied in recent years, it is always inspired by thoughts of its future utility. There is in most of the latest politically orthodox works an emphasis on the need to see the tasks of scientific research primarily in relation to their practical value: for example, in the story by Gennadi Gor 'Universitetskaya naberezhnaya' (The University Quay, *Neva*, 1959/11 and 12), and in the short novel by Nikolai Dementiev 'Prekrasna zima v Sibiri' (The Winter is glorious in Siberia, *Zvezda*, 1960/11 and 12), there is a demand for the assimilation or combination of physical and intellectual work, to which there are signs of growing resistance in the Soviet Union. In the somewhat longer story 'Povest o khlorelle' by Aleksandr Popovsky, a writer of very modest literary

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attainments, which appeared in 1963, there is an elderly biologist who by a very roundabout route finally comes to see that ' in our age the scholar's duty is to consider the current needs of his own country and not to live for remote goals '.

DISCUSSION of the effects of the Stalin era on science and scientists has led to some candid utterances in Soviet literature. The rising generation has no direct knowledge of the times ' when one was compelled to keep silent, when it was impossible to speak one's thoughts, when the result of scientific discussions was decided in advance ', as Granin puts it. In many cases the older generation of scientists seems to have been broken in spirit by that age, no longer able to work at the top of their form. Fear is still too much alive in them. Granin writes of one of the main characters in *Idu na grozu*, an academician, ' In recent years Golitsyn had felt with ever increasing agony the pusillanimity of his own mental processes. Old age was not the reason. The changes that had taken place after the twentieth Party congress had also affected the Institute: it was possible to extend the range of subjects, bring in new people, and freely discuss adjoining fields of study. But this was no real comfort to Golitsyn. How strange that he should still feel inhibited now that nothing hindered him any longer '.

However, by no means all the scientists of the older generation have been marked so deeply by the Stalin era. Professor Laginov, in Grekova's ' Za prokhodnoy ', gives the impression of being anything but a broken man. At the same time he does illuminate in a very striking way the difference between the fathers and sons, above all in regard to his level of culture. His team is proud of its chief, he is loved but not understood. It is not his personal qualities that make him seem so mysterious; it is rather his all-round culture which enables him to stand above things and see them from a lofty standpoint which is often beyond the range of his colleagues. Furthermore: ' Apart from ordinary prosaic knowledge his head was full of superfluous and even irrelevant facts. For example, he knew by heart the days on which Easter will fall for a whole century '. He knew the names of all the American presidents, had some understanding of brandy and wine, painted in a completely unorthodox and incomprehensible manner, and also wrote poetry.

Certainly, all these things do not necessarily provide the basis for successful scientific work, but they do mark the man out, extend his vision and powers of judgment, and enable him to lift his own particular subject out of a narrow rut and relate it to other fields of knowledge. The younger scientists striving eagerly for continuity with the past may well have the Laginovs in mind while at the same time they try to create their own traditions and lay the foundations for a better future.

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VIEWS AND REVIEWS

THE RSDLP

Abraham Ascher

MR. KEEP'S STUDY OF THE FORMATIVE YEARS of Russian Social-Democracy is the most exhaustive to appear in English.* After introducing his subject with a chapter on Russian Marxism during the 1880s and 1890s, Keep traces in detail the history of the Social-Democratic party from its founding in 1898 through the Revolution of 1905. With admirable succinctness he analyses the various theoretical disputes that played so important a part in this period and manages to disentangle some complicated issues. There are fine sections throughout on the organisation of the party, and the narrative is always related to developments in Russia itself.

The author's most striking interpretation appears in the first part of the book. He argues that the original leaders of Russian Marxism were so dogmatic, intolerant, and ruthless that even before the advent of Bolshevism the movement was 'permanently disfigured'. Very early Russian Social-Democracy acquired 'some of its less attractive characteristics: a Byzantine capacity for intrigue, a fanatical intolerance towards heretical opinions, and a disposition to settle arguments by the use of force'. Keep suggests that in their political behaviour the leaders cared more for power than for ideology, particularly during the 'economist' and 'revisionist' controversies at the turn of the century. In his view these 'bitter polemics . . . served as a smoke-screen to conceal what was essentially a struggle for power and influence among rival groups'.

In support of his thesis Keep has culled evidence from a wide range of sources and there is no doubt that he presents a strong case. The leading social-democrats were not noted for reasonable or genteel political behaviour. Still, in probing their motives—always a treacherous task for the historian—Keep may have put too much stress on the Marxists' quest for power for its own sake. After all, these men had dedicated their lives to the realisation of an idea: precisely because they adhered to an 'all-embracing ideological creed' they believed, especially in this early period, that the slightest deviation would lead the movement to disaster. Even the most ruthless polemicists, Plekhanov and Lenin, may have been driven to excess less by an overriding desire for power than by a tendency to regard themselves as the guardians of othodoxy. Keep is aware that these other motives came into play, but in his actual analyses he tends to ignore them.

In any case, perhaps because of his animus against the founders of Russian social-democracy, Keep occasionally presses his interpretation harder than the evidence permits. A few examples will suffice to show this. Keep claims that in the late 1890s Plekhanov believed that his opponents within the movement ought to be 'crushed by force'; only lack of the 'means of coercion' prevented him from doing so. This is

* J. L. H. Keep, **The Rise of Social Democracy in Russia.** Clarendon Press, Oxford, 1963.

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an arresting revelation, but the author fails to document it. In his discussion of the attempted reconciliation in 1901 between the orthodox Marxists and the alleged economists, Keep dismisses as 'trivial' some last-minute changes suggested by the latter in a draft agreement that was to have served as the basis for the rapprochement. The onus for the collapse of the negotiations therefore falls entirely on the orthodox, who found the new version unacceptable. A close reading of the amendments, however, reveals that some were designed to give the agreement a substantially new slant. Finally, Keep charges—without persuasive evidence—that the harsh tactics of the orthodox leaders during the 'economist' controversy were 'all the more reprehensible' because they were themselves sympathetic to revisionism. On the basis of a casual remark in a long letter, he attributes revisionist leanings to Axelrod, despite the discrepancy between this remark and the views expressed in Axelrod's many other letters and published works. In fact, in another long letter Axelrod explained why Bernstein had mistakenly assumed he was a kindred soul, and made it absolutely clear that he had no use for revisionism.

These caveats notwithstanding, Keep's book is a valuable contribution. Especially noteworthy is his thorough account of the preparations for the second congress in 1903, the scene of the 'Great Schism' between Menshevism and Bolshevism, of the debates held there and the manouevres of the factions. The discussion of the tactics against tsarism advocated by the two factions in the year and a half after the ill-fated congress is useful in showing how the two groups were beginning to diverge on issues rather more fundamental than those that seemed to be the cause of the rift. Keep's treatment of social-democracy's role in the Revolution of 1905, the first scholarly examination of the subject, convincingly demonstrates that the organisational weakness of the Bolsheviks and Mensheviks was responsible for the failure of their strategies. No one interested in the history of socialism or of modern Russia will fail to benefit from reading this book.

SOVIET DILEMMAS

Eugene Kamenka

A GREAT DEAL OF THE MUCH-IMPROVED Sovietological writing of the last decade still falls far too readily into one of two groups: the political-journalistic and the academic-pedestrian. The consistent merit of Professor Ulam's work has been its eschewal of these two categories; for one who is sympathetic to the problems of politicians and the practical needs of government, Professor Ulam has unusual historical sense and imagination, a genuine appreciation of social forces, and a sharp eye for the distinction between the trivial and the important, between the current pose and the lasting dilemma. Communism, to him, is neither an immutable dogma nor a day-to-day conspiracy; it is an historic movement that must be studied as such.

It is with communism as an historical movement, and the resultant dilemmas that confront Soviet leaders, that Professor Ulam is concerned

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in his latest collection of articles, issued under the title *The New Face of Soviet Totalitarianism*.* The dilemmas are seen as springing from the historical role of Marxism as an ideology suited only to agrarian societies undergoing industrialisation, an industrialisation now reaching completion in the Soviet Union. Marxism, Professor Ulam argues in the first chapter (as he had earlier argued in his book *The Unfinished Revolution*), 'receives its historical significance from its ability to combine anarchism —the most violent protest against industrialism—with an intense cult of technology and a conviction of the historical necessity and blessings of industrialism'. Marxism thus becomes (as it became in Germany) the educator of the working class in the transition to a fully industrial life. But when the industrial society and the industrial ethos have been established (as they were in Germany around 1900, and in England earlier), Marxism loses its relevance: the workers turn to labourism and the demand for better housing and higher wages, the middle classes look to status and security. From about 1900 onward, the 'Marxism' of the German Social-Democratic Party served only to frighten the middle classes: it had no significant effect on social policies or even on the practical demands of the working-class and of the SPD itself.

In Russia, towards the end of the 19th century, on the other hand, Marxism *was* relevant, as it is relevant in agrarian societies turning towards industrialisation today. Russia was being rapidly precipitated into the industrial age, while her society was of the type to maximise anarchist reactions. It was on a wave of anarchist reaction that the Bolsheviks came to power in 1917, when Lenin deliberately deepened the anarchist content of Marxism; then that anarchism had to be eradicated—to be replaced, by means of NEP, ideological pressure, State organisation and violence and terror, by a centralised technology and an industrialised society.

Over large areas of Soviet society this task has been so successfully accomplished that many Soviet citizens must now be wondering whether Marxism and the Communist Party as they know it any longer have a useful task to perform. In one crucial respect, however, the Bolsheviks have failed. The peasant remaining on the land has not been successfully integrated into the industrial society. Like the medieval *glebae adscripti*, he is a forced labourer who would like to be a farmer. Communism cannot allow him to become a kulak and cannot make him produce as an agricultural worker. Thus, 'Marxism in Russia is confronted by the industrial state which it has created and which does not need it any more, and by a peasant society which, having provided the rationale for Marxism, has not proved susceptible to Marxist solution' (p. 42).

In the remaining six essays of this book, Professor Ulam returns, one way and another, to the dilemmas of a Communist Party which is abolishing the historical conditions for its existence, which is producing new classes with new outlooks, and which still cannot assimilate or abolish the peasant. In an essay on Stalin he traces the final destruction of the humane and democratic forces in Russian Marxism and in Russian society. Other essays consider Khrushchev's rise to power, the history of Soviet foreign policy, the rôle played by nationalism, panslavism and

* Adam B. Ulam, **The New Face of Soviet Totalitarianism.** Harvard U.P., Oxford U.P., 1963. 40s.

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communism respectively in determining this foreign policy, the treatment of socialism in Soviet historiography, and the problems facing Khrushchev at home and abroad. Khrushchev's era, Professor Ulam argues together with most of us, ' has meant the introduction of enlightened totalitarianism in the USSR and a conscious effort to dispense with the pathological, uneconomic, and plainly unnecessary aspects of totalitarianism inherited from Stalin '.

Apart from a good deal of competent but fairly familiar analysis of recent Soviet history, which will interest the general reader but hardly excite the specialist, Professor Ulam has one main additional point to offer. The Communist Party of the Soviet Union today must live primarily on its wits: it can resolve the paradox of retaining totalitarian power over an industrialised and literate society only by seeking to demonstrate to its citizens, in a fairly *ad hoc* manner, the triumphs of communist society over parliamentary democracy. This may result, Professor Ulam suggests, in increasing stress on the achievements of communism outside the Soviet Union, where Khrushchev probably confidently expects time and the absence of armed intervention by either side to favour communism in the underdeveloped countries.

Professor Ulam, one suspects, has been too busy to write a book; the theme with which he began is not developed, the variety of paradoxes he rightly discovers is not brought into a related whole. The problem of the peasantry could and should have been explored further, the basic dilemmas of Soviet foreign policy should have been discussed in more detail, the forces favouring communism in underdeveloped countries should have been studied more fully and balanced against what Professor Ulam calls the Algerias and Cypruses of the Soviet camp: Yugoslavia, Hungary, and Poland, not to mention China. In short, one excellent preliminary article is followed by six more excellent preliminary articles. With the number of articles being written, it is time for a book.

LIMITED WAR

David Footman

A GREAT deal has been written, and indeed forgotten, about the war in Korea: but hitherto there has been no satisfactory account of the war as a whole, giving not only the purely military operations, but also their political background in the setting of the world situation at the time. Such a work has now appeared in *Korea: the Limited War*.* It has, of course, entailed considerable research: Mr Rees has covered a formidable mass of source material. But the immediately striking feature of the book is its extreme readability. Each section, whether dealing with the actual fighting, with the problems facing the leaders, or with the political issues at home, is in itself an exciting story. And the sections are so arranged and presented as to build up a consistent and satisfying piece of history, with implications, as the author convincingly shows, that are very relevant to the state of the world today.

* David Rees, **Korea: The Limited War,** pp. xvi plus 511. Macmillan, 1963, 50s.

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Limited war is war as defined by Clausewitz, a continuation of politics by other means. Its aim is ' to affect the opponent's will, not to crush it '. But to the liberal puritan mind war can only be justified when it is fought as a crusade to exterminate evil. And once the crusading spirit gets a grip on public feeling the task of leaders of democracies becomes difficult, all the more so when the enemy is imbued with ' the communist belief in the absolute supremacy of political considerations in war, combined with their surgical skill in using force to advance their long term aim '.

If there is a hero to the book it is, perhaps, President Truman, who took the tough decision to resist and thereafter showed courage and persistence in keeping the war within limits. Then there is General Ridgway, who assumed command when the war was at its grimmest and who restored morale by cutting out sentimental pep-talk and teaching the troops to fight because they were told to. But, throughout, the crusaders are treated with scrupulous fairness. No one has disproved MacArthur's contention that time is not on our side. It cannot be shown that Van Fleet was wrong when he claimed that in the summer of 1951 ' we had the Chinese whipped '. And there is good evidence that it was the threat of the atom bomb that at last induced the enemy to agree to a truce.

Korea: the Limited War, not only gives an admirable account of the main issues involved, but is equally good on the highly significant incidentals. The section on indoctrination or brainwashing in the communist P.o.W. camps is balanced and convincing, as is the account of the Bacteriological Warfare campaign. And there are fleeting reminders of the nonsense so heatedly believed and proclaimed by British left-wing intellectuals. All in all Mr Rees has accomplished a first-class piece of work. The book is well presented, with excellent photographs. The maps are adequate for the understanding of the campaigns they illustrate, but some readers will regret the absence of a general map of Korea. And with so many unfamiliar abbreviations the glossary might well have been placed at the beginning of the book instead of being tucked away towards the end.

MARGINAL NOTES ON A JOURNAL

Tamas Aczel

ALMOST TEN YEARS AGO, in the summer of 1955, Jozsef Darvas, the then Hungarian Minister of Education, invited a number of writers to a meeting in his office. It was to discuss the publication in Hungarian of Hemingway's book, *The Old Man and the Sea*; the writers insisted on it, the party opposed it. The Minister's task was to convince the writers of the ' anti-party ' character of their point of view, and to prove to them that Hemingway's work was an example of ' the despondency and inhumanity of bourgeois decadence '. The meeting, needless to say, was fruitless. Neither the writers nor the party changed their views and as the party was in a position to prevent the writers from achieving their

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object, Hemingway's novel remained in the drawer of the editor's desk. The single copy that was available in the country went from hand to hand (as did the single copy of George Orwell's *1984* and Arthur Koestler's *Arrow in the Blue*), but the non-English-speaking section of the public was unable to read the book for another year. Then, however, after the fall of Rakosi, Hemingway's 'bourgeois decadence' was suddenly transformed into 'a masterful symbol of progressive humanity's struggle', and the book appeared in Hungarian translation in the windows of the bookshops. The first edition was snapped up within a few hours, and other editions followed.

In the same year a new periodical was launched, with the specific aim of giving voice to those latent aspirations which, however concealed, suppressed, or masked, persisted in the country's cultural life and aimed at connecting, or rather re-connecting, Hungary's culture, literature, and intellectual life with the Western mainstream. The name of the journal, *The Wide World*, reflected this purpose. In this way, after ten years of a cultural wasteland, when the worst Soviet work of art had to be considered superior to the best American, a wave of fresh air blew over the country in the months preceding the Revolution, and it is one of the greatest achievements of the Revolution that this current of fresh air is still invigorating the atmosphere of the country to this day.

The Wide World * endeavours to acquaint the Hungarian reader with the main trends and tendencies of modern literature. Not only does it mark a great step forward towards the liberation of cultural and intellectual life; it is also an experiment in trying to introduce, concentrate, and evaluate the main works and trends of the literature of our age.

Obviously, a periodical which was born as a compromise in the conflict between the reading public's requirements and party tactics, will bear the marks of compromise. Readers want an unbiased presentation of the works, while the party machine is bent on thwarting them, and this is reflected in *The Wide World* in a disharmony between presentation and interpretation. The plays, poems, and stories which, more often than not, have nothing to do with Marxism, have to be interpreted for the reader in a Marxist-Leninist spirit. The reader is taken by the hand and guided through the cosmopolitan jungle of the West. For, as one of the party's spokesmen on culture, Peter Renyi, points out (No. 2, 1964): 'a peculiar, ambivalent relationship has developed between our intelligentsia and the bourgeois West. . . . some of our intellectuals see the bourgeoisie as a kind of spiritual concept which they associate with humanitarianism, love of freedom, and mental independence', whereas in that selfsame West 'capitalist bourgeois existence reeks of money and the bourgeois classes exploit, speculate, and enrich themselves on armaments'. This—according to Renyi—goes to prove that 'we have to meet the challenge of this type of ambivalence', and it is precisely in the pages of *The Wide World* that this particular ambivalence is reflected. Its task is clear. It has to publish those works 'which refer to the positive aspects of today's capitalism and do not drown everything in a nihilistic denial', as these 'frequently exert a positive influence on the thoughts and feelings of our intellectuals and fortify their anti-capitalist

* Editor Laszlo Kardos, university professor; deputy editor, Laszlo Geredlyes, poet.

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emotions', and at the same time 'one has to argue with them, one has to unmask them, as it is evident that the publication of Western works and plays is a battle and not some kind of agreement—we are not presenting Western works and plays for the purpose of spreading their message or for information'. The conflict between party tactics and the requirements of the public could hardly be expressed more concisely. Luckily for *The Wide World*, however, this kind of oracular revelation does not appear too often in its pages. What does?

APART FROM THE FORBIDDEN FRUITS of Camus, Becket, Genet, whose 'visions of doom (to quote Renyi) are directed not against capitalism alone, but against all forms of society and so, in the final analysis, against humanity itself', the reader can sample a great number of outstanding works of both Eastern and Western literature. The small window is in fact opened wide. It is gratifying to see the names following one another in peaceful coexistence. For here, without controversy, are lined up side by side John Steinbeck's *Flight* and Francoise Sagan's *Un Certain Sourire*, and Solzhenitsyn's *One Day*; Margaret Duras' *The Afternoon of Mr. Andesmas* and Arthur Miller's *The Misfits*; Hochhut's *The Representative* (Act 4); Leonid Pervomaisky's *Modern Ballad* and so on and so on.

This brief list, by no means complete, indicates the rich fare *The Wide World* provides for its readers; for the last nine years, month by month, it has publicised those works which can lay rightful claim to the attention of Hungarian writers and readers. To it could be added the names of Duerrenmatt, Robbe Grillet, Graham Greene, Sartre, Max Frisch, Alan Sillitoe, William Faulkner, Ilya Ehrenburg, Italo Calvino, Alfred Andersch, Guenther Grass, Juan Goytisolo, Victor Nekrasov, Leonid Leonov, Alberto Moravia, Salinger, Bernard Malamud, Ionesco, and many others. The poets, Russian, French, or American, bourgeois or revolutionary, are well represented. If we add that despite the repeated warnings of the party, space is also found for Camus and Becket, and that *The Wide World* was the first periodical in Hungary to publish the writings of Franz Kafka, we get some idea of the scope of its work in informing the Hungarian reading public. It is largely due to this periodical that the Hungarian public has learned about the 'nouvelle vague', 'nouveau roman', and 'Cinéma Vérité', that Kierkegaard today is no longer an 'imperialist hyena' but 'that lonely man who in Denmark, his homeland, gave voice to those same problems which ever since have been played out as variations on a theme by his less talented, less fertile, and less consistent successors', and that Huxley's *The Island* can be described as 'having a number of beautiful thoughts and ideas on individual happiness, and is right in saying that there is room for improvement in the ways of community living . . . and we could also learn a great deal from him in the application of biological and psychological factors for the good of the individual and the community'. It informs its readers about what is happening in Turkish literature, and about the literary arguments raging in the Soviet Union, reporting word for word the attack of the official party representatives and the defence, comments, or self-criticism of the poets, without putting any interpretation on the words.

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WHAT PRICE HAS TO BE PAID for this display of these discriminating analyses, which cover the field of literature from Horace to Salinger? The answer can be found firstly in the selection and grouping of the material, secondly in the ideological commentary on it. The editors, understandably enough, take the line of least resistance, and while undoubtedly making a creditable effort to present—in addition to communist or fellow-traveller writings—a complete picture of Western literature as a whole, they present it as a literature exposing the ills of capitalism. Arthur Miller, Fellini, Graham Greene, Edward Albee, or William Saroyan are frequently defined as writers 'who unmask the process of imperialist dehumanisation'; Western literature is transformed into arguments supporting Marxist-Leninist ideology, and is made to underline and justify the party's principles: the poem, play, or novel providing the practical example on which to unfold and prove the party's theory.

Fortunately *The Wide World* does not often commit such absurd blunders as it did in omitting from Duerrenmatt's play *The Physicists* the entire scene in which the aims and intentions of the diverse Governments are presented by their respective agents. But it is such blunders which reveal the essence of the periodical's dilemma—the apparently insoluble problem of how to present and evaluate those works which, while anti-capitalist and anti-fascist, are, at the same time, anti-communist as well, not in the way of cold-war propaganda, but simply because they are opposed to all dehumanisation and to every kind of totalitarianism. This is where ideology takes over from objectivity. Thus Kafka's vision is turned into a trial of the Habsburg Monarchy 'that is dangerous even in its decline', and 'the allegedly anarchistic Eugene Ionesco' is said to be 'not so very far removed from the conservative and traditional Karl Kraus; thus we are informed that 'Modern American poetry is the elemental outcry of unlovedness, of spiritual, intellectual, sexual, and political despair', that the moral of Max Frisch's modern mystery-play, *The Fireraisers*, is 'that it proves that individual possessions, people's attachment to them as well as their abhorrence of change, is what plunges the world into war', that Gruppe 47, 'in order to safeguard their existence and escape the danger of being regarded as communist sympathisers have to weave into their work—often grotesquely—some anti-communist threads'.

It is obvious that the greatest problem confronting the editors of *The Wide World* is that of the European and American leftist intellectuals. The solution, in most cases, is a simple one: to put a one-sided emphasis on their anti-capitalism, while their rejection of communism is rationalised by reference to 'bourgeois restrictions', 'false consciousness', or, as in the case of Duerrenmatt or Gruppe 47, by the need 'to safeguard their existence'. The editors have developed a severe complex about these writers who reject both capitalism and communism; they return to them over and over again, encircling them, approaching them from different angles, probing the depth of their human values or the shallowness of their political convictions, as if trying to convince themselves of the accuracy of their analysis. So the Kafka-case, the Camus-case, the Duerrenmatt-case, the Frisch-case, the Moravia-case, surpass their own significance and become symbols of self-justification and self-acquittal, which explain and excuse the principles and political views

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of the editors. Moravia, for instance, does not understand that 'the freedom to be independent of everyone is a lesser freedom than that of belonging to recognised, real forces', for although 'violations of the law have indeed happened, the misuse of power is not the legitimate characteristic of the people's rule; on the contrary, it is an aberration of the people's rule, hostile to the people's interest, at variance with and in contradiction to communist politics'. Of Camus' work we learn that it 'shows clearly that the commendable virtues of opposition and human solidarity are in themselves unable to give any kind of support unless they are coupled with intelligent and purposeful social efforts and intentions'.

All this, fortunately, only disturbs those who read the interpretations as well as the works, and who might well ask the editors why, if they publish Mayakovsky's hitherto unknown farewell letter written before he committed suicide, they do not publish the reason for his suicide as well? Or why, if they publish Pasternak's poems in excellent translations they say of the poet that 'his figure has been shrouded in confusing mist by Western papers, which used him for political sensationalism', when *Dr. Zhivago* has not been translated or published in Hungary. But this matters only to those who care about the political-strategical side of the compromise. Those—and they are in the majority—whose sole interest is centred on the works themselves can relax and enjoy themselves.

THE PARIS COMMUNE

F. L. Carsten

IN MARXIST THOUGHT THE COMMUNE OF 1871 has occupied an exalted place ever since Marx wrote his celebrated pamphlet, *The Civil War in France*, in its honour. Fostered by Marx himself, the legend grew up that this was the first proletarian revolution, a model to be followed by others, while in reality it was a patriotic rising against the 'treason' of the Versailles government and its ineptness in the prosecution of the war against Germany. Moreover, the revolt was Jacobin and Blanquist in character, in the best tradition of the great 'days' of Paris in the years after 1789; Marx exercised no influence on the course of events, but for political reasons identified himself with them. As early as 12 April 1871 he declared in a private letter that the rising 'is the most glorious deed of our party since the June insurrection' (of 1848). In view of the place of this legend in the writings of Kautsky, Luxemburg, Lenin, and many others, it is politically important to trace its history during the half-century following upon its birth. The author of the book under review * has not confined his labours to socialist and Marxist thought, but includes also the comments and reactions of Bismarck's government and of anti-socialist writers and politicians in Germany. Just like the October

* Günter Grützner, **Die Pariser Kommune—Macht und Karriere einer politischen Legende**, Westdeutscher Verlag, Cologne and Opladen, 1963. DM 29.

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revolution almost fifty years later, the commune produced fear and a shock effect among the German middle classes, leading to increased persecution of the social-democrats and finally to the anti-socialist law of 1878. Persecution was stepped up by the declarations of solidarity with the Communards emanating from the social-democratic deputies and press: their enthusiasm was fired by the disaster that had overtaken their French comrades. Yet they—and the author of this book—overlooked that Marx, in 1881, clearly dissociated himself from the Commune: 'apart from the fact that this was merely the rising of a city under exceptional conditions, the majority of the Commune was in no way socialist, nor could it be. With a modicum of common-sense, however, it could have reached a compromise with Versailles useful to the whole people . . .' he wrote in a letter of 22 February 1881. Paradoxically, the socialist movement drew inspiration from a movement which lacked this 'modicum of common-sense', and in 1917 Lenin based his famous pamphlet, *The State and Revolution*, on a completely mistaken view of the events of the Commune. If this new book is somewhat laborious and reads too much like a calendar of Marxist and anti-Marxist writings on the subject, it was nevertheless worth making the effort, for nothing in politics is so tenacious as a myth.

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